VOL. XIV OCTOBER 1960 NO. 4

PACIFIC SCIENCE

A QUARTERLY DEVOTED TO THE BIOLOGICAL AND PHYSICAL SCIENCES OF THE PACIFIC REGION

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Flora of Eniwetok Atoll[1]

HAROLD ST. JOHN[2]

ENIWETOK ATOLL is near the north end of the Marshall Islands which form the northeastern part of Micronesia, in the tropical, central Pacific Ocean. The Marshall Islands were discovered in 1817 on the "Rurik" voyage under Captain Otto von Kotzebue. A member of the scientific staff of this voyage was the German botanist, Adelbert von Chamisso. He made extensive plant collections in the Marshalls and included them in his publications on the voyage. Though this voyage of discovery included landings on several of the atolls, Eniwetok itself was not visited.

There are no accounts of the flora of Eniwetok during the successive occupations of Micronesia by the Spanish, or by the Germans. Next in the succession of rulers were the Japanese. Their scientists made wide explorations of Micronesia, and particularly through the work of R. Kanehira and T. Hosokawa added much to the knowledge of the Micronesian flora. In August, 1934, Ohba made collections of several species of *Pandanus*, these being apparently the first botanical collections from Eniwetok Atoll. They were studied, and published upon, by Kanehira, and are preserved in the herbarium at Fukuoka, Japan.

In World War II, during the American conquest, in February, 1944, there was heavy bombardment and fighting on Eniwetok. This caused general devastation on the largest islet, Eniwetok Islet, and on several others. It probably exterminated some of the rarer plant species. During the occupation of Eniwetok by the American military forces, Major Edwin H. Bryan, Jr., visited the atoll in August, 1944. He collected plant specimens and made additional notes on the flora. These gave the first general summary of the flora of Eniwetok. They are now in the Bernice P. Bishop Museum, Honolulu.

In mid-May, 1946, the ship of the Economic Survey of Micronesia, U. S. Commercial Corporation, tarried in the Eniwetok lagoon. Large botanical collections were made for it by F. Raymond Fosberg and a small collection by Edward Y. Hosaka. These collections are preserved in the U. S. National Herbarium, Washington, D.C., and in the Bishop Museum.

Broad scientific studies began in the area in connection with the American atomic bomb testing program. The first test shot was at Bikini Atoll in 1946. Connected with this were the investigations accomplished by the Crossroads Expedition. On its staff was William Randolph Taylor. In late May, 1946, he made collections on several of the islets of Eniwetok. They are preserved in the U. S. National Herbarium, the University of Michigan Museum, and the Bishop Museum. The plants of Eniwetok were included in Taylor's book, *Plants of Bikini, and Other Northern Marshall Islands*, 1950.

During August, 1949, the ship of the L. R. Donaldson Expedition, U. S. Atomic Energy Commission, was the base for investigations of the lagoon and the islets. The writer, H. St. John, was the botanist and ecologist for the terrestrial flora. His numerous collections are in the Bishop Museum, the Smithsonian Institution, Washington, D.C., the University of Washington, Seattle, and elsewhere.

On August 1, 1956, S. C. Rainey collected on Rigili. His specimens were identified by F. R. Fosberg in Washington, D.C.

In August and September, 1957, Irwin E. Lane collected on several of the islets. His specimens are in the Bishop Museum.

In early August, 1958, St. John collected on several of the southern islets of the atoll. His collections are in the Bishop Museum, and the Marine Biological Laboratory, Eniwetok.

[1] This report has been submitted to and cleared for publication by the U. S. Atomic Energy Commission.

[2] Visiting Professor of Botany, Chatham College, Pittsburgh, Pennsylvania. Manuscript received June 20, 1959.

LOCATION AND TOPOGRAPHY

Eniwetok Atoll is found near the northern end of the double chain of atolls forming the Marshall Islands. It is at 11° 30′ N., 162° 14′ E. Its shape is a broad ellipse, running NW to SE. Its length is 22 nautical mi. The reef is well developed and nearly continuous, but with several deep passages from the sea to the lagoon. The islets total 39, and nearly all of them and all the large ones lie on the northeastern or windward side. The largest islets are Eniwetok, Parry, Engebi, and Runit. Eniwetok, the largest, is 2¼ nautical mi. in length.

SIZE OF THE FLORA

Eniwetok is in the northern and drier section of the Marshall Islands. As a consequence it does not have, and probably never had, dense, lush, damp forests, nor is its total flora large. Its indigenous flora totals 42 species or minor taxa, of which 4 are endemic, all of these four being in the genus *Pandanus*. The total of adventive weeds is 27, and that of cultivated plants, including both food crops and ornamentals is 26. Species known only by drifted seeds on the beaches total 7. All together the living flora totals 95 species or minor taxa.

Seeds or fruits found in the jetsam on the sea and lagoon beaches add an element in the flora. Many come from species growing on the islets of the atoll, but there are others from species unknown on the island and certainly floated on the sea currents or waves from distant regions. Of these *Hernandia sonora* is the only one that is native to other islands of the Marshall group, ones to the south in the wetter belt. Two species, *Caesalpinia Bonduc* and *Aleurites moluccana*, are of wide occurrence and could have come from the northeast, south, or west. These are both abundant in Hawaii. Two species, *Mucuna urens* and *Sapindus Saponaria*, must have come from the northeast, being abundant in Hawaii and absent in other parts of the tropical Pacific. Two species, *Dioclea reflexa* and *Entada phaseoloides*, must have come from the south or west. In sum, of the 6 drift species, 4 certainly floated from Hawaii on the Japan Current which regularly flows past Hawaii towards the Marshalls and the central Pacific. The two species of southern or western origin may have travelled eastward on the Equatorial Counter Current and have been wafted northward during a southerly storm.

ECOLOGY

Details of the terrestrial plant ecology were reported to the Atomic Energy Commission in 1950. They were for publication in UWFL-24.

Because of the dryness and the small, mostly narrow, islets, there is little diversity in the habitats. There are no good sand dunes, or fresh ponds, or central hollows with rich, black humus top soil. The only habitats are: outer beaches of coral rock or coral gravel, inner beaches of coral sand, small coral sand dunes, coral gravel flats, and coral sand flats. Some of the plants seem restricted to a particular habitat, but the zones formed are rather indefinite. Their occurrence seems governed not so much by the soil, as by the size of the islet and the distance from the sea which seems to determine the shelter from salt spray, and the availability of fresh water in the water table. Since the habitat differences are slight, they have, for the sake of brevity, been omitted in the descriptive flora which follows, except when special and very local. In this flora every known collection is briefly cited with its islet, date of collection, and collector's name and the number. From this, future research workers can learn the former occurrence of each species, and the date for each record. This chronological information is of value, since it appears that each atomic bomb explosion has restricted, or may restrict, the occurrence of, or exterminate some members of, the flora.

ACKNOWLEDGMENTS

The author's sincere thanks are due Dr. Lauren R. Donaldson of the Radiation Biological Laboratory, University of Washington, Seattle 5, Washington, and Dr. Leonard D. Tuthill, then dean of the Graduate School, University of Hawaii, Honolulu 14, Hawaii, for making possible the writer's two explorations of Eniwetok.

PURPOSE

This account of the flora of Eniwetok is prepared in the form of a brief manual. It summarizes the flora, and it gives keys and brief descriptions to make possible the identification in the field of any of its plant species. Many types of research are being carried on now on the atoll. The investigators have diverse training and come from widely separated institutes. When their researches touch the terrestrial flora this manual will enable them to determine with certainty the identity of the plants.

KEY TO SPECIES

PTERIDOPHYTA

1. Plants lacking flowers, reproducing by spores; frond pinnately lobed ..... 1. *Phymatodes Scolopendria*
1. Plants with flowers, reproducing by seeds,

SPERMATOPHYTA

2. Flower parts in 3's; leaves parallel veined; herbs, and trees but these without secondary wood,

MONOCOTYLEDONES

3. Trees,
   4. Fruits aggregate into heads 15 cm. or more in length,
      5. Carpel apices concave,
         6. Phalanges 7.5–8 cm. long,
            7. Inner apical sinuses 2–3 mm. deep; syncarps globose ..... 2. *Pandanus brachypodus*
            7. Inner apical sinuses 1–2 mm. deep; syncarps ellipsoid ..... 3. *P. enchabiensis*
         6. Phalanges 6.5 cm. long; sinuses 2–3 mm. deep ..... 8. *P. rectangulatus*
      5. Carpel apices all, or at least the inner ones, convex or conical,
         8. Phalanges 7–9 cm. long,
            9. Inner apical sinuses 1–2 mm. deep; outer carpels much the larger ..... 7. *P. pulposus*
            9. Inner apical sinuses 3–6 mm. deep; outer carpels not much the larger,
               10. Phalanges 7–7.9 cm. long; tips of outer carpels conic and slightly divergent ..... 9. *P. rhombocarpus*
               10. Phalanges 9 cm. long; tips of carpels pyramidal-semiorbicular, ascending ..... 10. *P. Utiyamai*
         8. Phalanges 5.5–6.5 cm. long,
            11. Phalanges 6-6.5 cm. long; inner apical sinuses 6–7 mm. deep ..... 4. *P. korrorensis*
            11. Phalanges 5–6 cm. long; inner apical sinuses much shallower,
               12. Carpel apices rounded conic; phalange apices mostly convex; lateral sutures deep ..... 6. *P. odoratissimus* var. *novo-guineensis*
               12. Carpel apices truncate to low rounded; phalange apices mostly truncate; lateral sutures lacking or few and shallow ..... 5. *P. odor.* var. *novo-caledonicus*
   4. Fruit of single, 1-celled nuts, with edible white meat and potable water ..... 30. *Cocos nucifera*
3. Herbs,
   13. Blade deeply lobed; umbel with dangling, threadlike, sterile branches ..... 33. *Tacca Leontopetaloides*
   13. Not so,
      14. Sepals 3; petals 3; ovary 3-celled,
         15. Ovary superior; leaves linear, terete ..... 31. *Allium Cepa*
         15. Ovary inferior; leaves broad strap-shaped, 7–10 cm. broad ..... 32. *Crinum asiaticum*

14. Perianth none or of dry scales, these often in 2 ranks,
16. Stems terete, jointed, mostly hollow; leaves 2-ranked; anthers versatile,
17. Spikelets 1–many-flowered, laterally compressed; articulation above the glumes,
18. Spikelets sessile on a continuous rhachis,
19. Spikelets opposite; spike terminal, solitary,
20. Spike 1.2–1.5 mm. thick.....19. *Lepturus repens* var. *repens*
20. Spike 1.7–2 mm. thick.....20. *L. repens* var. *occidentalis*
19. Spikelets on only one side of the rhachis; spikes usually several, digitate or racemose,
21. Spikelets with more than 1 perfect flower,
22. Rhachis of spike extending beyond the spikelets.....15. *Dactyloctenium aegyptium*
22. Rhachis of spike not prolonged.....17. *Eleusine indica*
21. Spikelets with only 1 of the florets perfect,
23. Spikelets without additional modified florets; rhachilla prolonged behind the palea.....14. *Cynodon Dactylon*
23. Spikelets with 1 or more upper modified florets.....13. *Chloris inflata*
18. Spikelets pediceled in open panicles; lemmas 3-nerved.....18. *Eragrostis amabilis*
17. Spikelets with 1 perfect terminal floret and 1 staminate or rudimentary one below; spikelets dorsally compressed; articulation below the spikelet,
24. Glumes and sterile lemma membranous,
25. Spikelets borne from the one furrowed side of the rhachis; plant creeping.....23. *Thuarea involuta*
25. Spikelets not so; plant erect,
26. Spikelets subtended or surrounded by bristles or spines,
27. Bristles connate at base, falling with the burlike spikelet,
28. Spikelets 5–6 mm. long; involucre pilose; first glume present.....12. *Cenchrus echinatus*
28. Spikelets 4 mm. long; involucre puberulous; first glume wanting.....11. *C. Brownii*
27. Bristles distinct, persisting on axis; spikelets discoid, falling free of the bristles.....21. *Setaria verticillata*
26. Spikelets not subtended by bristles,
29. Glumes and sterile lemma awned; spikelets long-silky.....25. *Tricholaena repens*
29. Glumes and sterile awnless,
30. Spikelets long-silky, in panicles; fruit lanceolate, acuminate.....24. *Tricachne insularis*
30. Spikelets short pubescent or glabrous; fruit elliptic; racemes quite or nearly digitate.....16. *Digitaria pruriens*
24. Glumes indurate; fertile lemma and palea hyaline or membranous; sterile lemma like the fertile one,
31. Spikelets unisexual, in separate inflorescences; individual ovaries naked.....25. *Zea Mays*
31. Spikelets in pairs or threes, one sessile and perfect, the others pedicelled and staminate.....22. *Sorghum bicolor* var. *technicum*

16. Stems triangular, solid; leaves 3-ranked; anthers basifixed,
32. Floral scales 2-ranked, laterally compressed,
33. Spikelets lanceolate; blades nodulose....27. *Cyperus javanicus*
33. Spikelets linear; blades not nodulose....28. *C. odoratus*
32. Floral scales spiral, merely concave....28. *Fimbristylis atollensis*

2. Flower parts in 5's (rarely in 4's); leaves netted veined; herbs, shrubs, or if trees with secondary wood.

DICOTYLEDONES

34. Leafless, cordlike parasites....48. *Cassytha filiformis*
34. Not so,
35. Perianth in 1 series or apparently so,
36. Leaves opposite,
37. Stipules present,
38. Ovary 3–4-celled,
39. Florets in heads surrounded by a calyxlike involucre; sap milky,
40. Stems prostrate; blades less than 1 cm. long....63. *Euphorbia thymifolia*
40. Stems erect; blades larger,
41. Blades glabrous; plant forming tufts....61. *E. Chamissonis*
41. Blades hirsute; stems simple....62. *E. hirta*
39. Flowers not in involucrate heads,
42. Outer stamens opposite the sepals; blades oblong-obovate, unlobed....64. *Phyllanthus amarus*
42. Outer stamens alternate with the sepals; blades suborbicular, deeply palmately lobed....65. *Ricinus communis*
38. Ovary 1-celled; fruit an achene....35. *Fleurya ruderalis*
37. Stipules none,
43. Perianth deeply 3–5-parted, dry, scarious,
44. Style single; stigma capitate,
45. Perianth 5 mm. long; blades rough hairy....37. *Achyranthes aspera*
45. Perianth 5.5–6.5 mm. long; blades soft silky hairy....38. *A. velutina*
44. Styles 2–3,
46. Sepals 3; pod not splitting at maturity....40. *Amaranthus viridis*
46. Sepals usually 5; pod splitting at maturity....39. *A. dubius*
43. Perianth funnelform, petaloid,
47. Tree; fruit with gland-tipped, spiny, longitudinal ridges....44. *Pisonia grandis*
47. Herbs; fruit not spiny ridged,
48. Flowers axillary, solitary, 2.5–5 cm. long....43. *Mirabilis Jalapa*
48. Flowers less than 5 mm. long, in terminal spikes,
49. Calyx tube glandular; stamens 2–3....41. *Boerhavia diffusa* var. *diffusa*
49. Calyx tube glabrous; stamens 3–6....42. *B. diffusa* var. *tetrandra*
36. Leaves alternate,
50. Fruits juicy, fused into a head; tree....34. *Artocarpus incisus*
50. Fruits dry capsules, distinct,
50A. Herbs (Turn back to the first no. 37.)
50A. Trees; fruit an achene enclosed in a loose, fleshy envelope....48a. *Hernandia sonora*
35. Perianth in 2 series or apparently so,
51. Parts of the inner perianth series all or all but 2 separate or united only at the very base,

52. Stamens more than twice as many as the petals,
53. Leaves opposite,
54. Stipules present,
55. Sepals 2; ovary 1-celled,
56. Leaves terete.....47. *Portulaca samoënsis*
56. Leaves flattened,
57. Petals 2–4 mm. long, closing at noon; leaves wedge-shaped.....46. *P. oleracea*
57. Petals 10–12 mm. long, closing at 3 P.M.; leaves obovate to orbicular.....45. *P. lutea*
55. Sepals more than 2; ovary several-celled,
58. Ovary partly inferior; fruit smooth, with single seed germinating while still on the tree.....71. *Rhizophora Mangle*
58. Ovary superior; capsules spiny; seeds germinating after falling.....66. *Triumfetta procumbens*
54. Stipules absent; filaments united into a tube,
59. Involucral bracts 3–1; ovule ascending.....67. *Malvastrum coromandelianum*
59. Involucral bracts none; ovule pendulous or horizontal.....68. *Sida fallax*
53. Leaves alternate.....60a. *Aleurites moluccana*
52. Stamens twice as many as petals or less,
60. Ovary inferior, 1-celled; trees,
60A. Sepals and petals 4–5; ovules 2–5; stamens 10.....72. *Terminalia samoensis*
60A. Sepals and petals 3; ovule 1; stamens 3–4.....48a. *Hernandia sonora*
60. Ovary superior,
61. Leaves compound,
61A. Trees; fruits globose.....65a. *Sapindus Saponaria*
61A. Vines or herbs,
62. Leaves opposite; ovary 5–6-celled, in fruit each coccus 2-horned.....59. *Tribulus cistoides*
62. Leaves alternate; ovary 1-celled, unarmed,
62A. Flowers regular; pods dehiscing into 1-seeded joints; seeds 4–5 cm. in diameter.....54. *Entada phaseoloides*
62A. Flowers papilionaceous; pods dehiscing longitudinally; seeds smaller,
63. Pod septate internally between the seeds.....55. *Mucuna urens*
63. Pods not thus septate,
64. Keel of corolla spiral.....56. *Phaseolus vulgaris*
64. Keel not spiral,
64A. Flowers with 4 petals regular, 1 slightly the larger; pods prickly.....52a. *Caesalpinia Bonduc*
64A. Flowers papilionaceous; pods smooth,
65. Style bearded towards the summit; upper stamen free.....58. *Vigna marina*
65. Style beardless near tip,
66. Calyx asymmetric from much enlarged upper lip; seeds beanlike; upper stamen connate to the middle.....54. *Canavalia microcarpa*
66. Calyx nearly symmetric; seeds compressed quadrate.....53a. *Dioclea reflexa*
61. Leaves simple; shrubs or trees,

67. Stipules present; petals white.....70. *Pemphis acidula*
67. Stipules absent,
68. Carpels several, dry, separate; petals yellow, glabrous.....60. *Suriana maritima*
68. Carpels 1 and single, or compound,
69. Columnar, fleshy trees with palmately dissected blades.....69. *Carica Papaya*
69. Not as above,
70. Stamens 6; petals 4, glabrous,
71. Pod terete, indehiscent, beaked; leaves pinnatifid.....52. *Raphanus sativus*
71. Pod flattened, dehiscent; leaves entire,
72. Leaves fleshy, glaucous; sepals erect.....49. *Brassica oleracea* cv *capitata*
72. Leaves thin, greenish; sepals spreading.....50. *B. pekinensis*
70. Stamens 8; petals 4, villous within.....36. *Ximenia americana*
51. Inner perianth series connate,
73. Ovary inferior,
74. Stipules present; trees,
75. Drupes fully united into compound, soft fruits.....83. *Morinda citrifolia*
75. Drupes remaining separate, firm, subglobose.....82. *Guettarda speciosa*
74. Stipules none,
76. Vines climbing by tendrils,
77. Corolla white.....87. *Lagenaria siceraria*
77. Corolla yellow,
78. Corolla lobed half way.....86. *Cucurbita maxima*
78. Corolla lobed nearly to the base,
79. Tendrils branched.....84. *Citrullus vulgaris*
79. Tendrils unbranched.....85. *Cucumis Melo*
76. Not so,
80. Flowers separate; corolla slit down upper side,
81. Leaves glabrous.....88. *Scaevola frutescens* var. *frutescens*
81. Leaves appressed pilosulous.....89. *S. frut.* var. *sericea*
80. Flowers assembled in involucrate heads,
82. Heads containing only ray flowers; sap milky.....91. *Lactuca sativa*
82. Heads with some or all of the flowers disk flowers,
83. Disk flowers the only ones present,
84. Corollas 5-parted; flowers all perfect, fertile.....94. *Vernonia cinerea*
84. All corollas except the central ones filiform, truncate, fertile,
85. Blades oblanceolate, serrate or denticulate, 2.5–3.7 cm. long.....92. *Pluchea indica*
85. Blades 10 or more cm. long, oblance-elliptic to lanceolate, entire or nearly so.....93. *P. odorata*
83. Disk flowers at the center, ray flowers on the margin of the head,
86. Ray flowers minute, not longer than the bracts.....90. *Erigeron bonariensis*
86. Ray flowers larger and conspicuous,
87. Blades sessile, entire; involucral bracts in several series.....96. *Zinnia elegans*
87. Blades petioled, serrate; involucral bracts in 2 series.....95. *Wedelia biflora*

73. Ovary superior,
88. Leaves in whorls of 3; tree with milky sap ..... 73. *Ochrosia oppositifolia*
88. Leaves alternate,
89. Ovules 1–2 in each cell,
90. Herbaceous vines,
91. Night-bloomer; corolla white ..... 76. *Ipomoea tuba*
91. Day-bloomer; corollas bluish to pinkish,
92. Blades cordate; flowers opening blue; plant not halophytic ..... 75. *I. purpurea*
92. Blades emarginate or rarely obtuse or acute; flowers opening pink; plant of salty shores ..... 74. *I. pes-caprae* subsp. *brasiliensis*
90. Trees,
93. Corolla white, about 5 mm. long; blades silky hairy ..... 78. *Messerschmidia argentea*
93. Corolla orange, about 4 cm. long; blades nearly glabrous ..... 77. *Cordia subcordata*
89. Ovules several to many in each cell,
94. Fruit a capsule ..... 79. *Nicotiana glauca*
94. Fruit a berry,
95. Anthers connivent around the style; berry red, exposed ..... 81. *Solanum Lycopersicum*
95. Anthers not connivent; berry yellowish, enclosed in the papery, enlarged calyx ..... 80. *Physalis angulata* var. *angulata*

FLORISTIC TREATMENT

PTERIDOPHYTA

POLYPODIACEAE

1. *Phymatodes Scolopendria* (Burm.) Ching; *Polypodium Phymatodes* L.; *Microsorium Scolopendria* (Burm.) Copel. "Kino." Rhizome scaly, pale, creeping on the ground; fronds remote; stipes 15–35 cm. long, dark; fronds 30–50 cm. long, ovate, firm, deeply pinnatifid; sori naked, round to elliptic, in a single row on either side of the midrib of the lobe.

Recorded for Eniwetok Atoll only in the field observations in 1944 of E. H. Bryan, Jr.

SPERMATOPHYTA

MONOCOTYLEDONES

PANDANACEAE

2. *Pandanus brachypodus* Kanehira. "Punmusi." Tree; leaves 180 × 6.5 cm., the margins denticulate, the teeth near the tip 1 mm. long, 3 per cm., the lower ones more distant, only near the middle are the teeth lacking; midrib unarmed below at base, armed above; heads 17 × 16 cm., nearly globose, of about 43 phalanges, these 7.5 cm. long, obovate, the apex truncate; carpels 5–6, the inner ones much the smaller, the apices concave, the inner sinuses 2–3 mm. deep.

Engebi: by the holotype collection (as Enchabi I.), August, 1934, *Hosino A 7* (*Kanehira 3,480*). Japtan: 6 August 1958, *St. John 26,303*.

3. *Pandanus enchabiensis* Kanehira. "Maok." Tree; fruiting head 24 × 18–20 cm.; ellipsoid, of about 50 phalanges, these 8 × 5 cm., obpyriform, the apex truncate; carpels 5–6, the inner ones much the smaller, the apices concave, the inner sinuses 1–2 mm. deep.

Engebi: (as Enchabi I.), August, 1934, *Ohba* (*Hosino A 15*), (*Kanehira 2,470*), holotype.

4. *Pandanus korrorensis* Kanehira. "Bop." Leaves 120 × 9 cm., the midrib denticulate below, the margins denticulate, the teeth near the apex 1 mm. long, towards the base larger and more remote; fruiting head 17 × 15 cm., broad ellipsoid, of about 70 phalanges, these 6–6.5 × 3 cm., obpyriform, the apex profile rounded; carpels 5–10, subequal, the apices depressed conic, the inner sinuses 6–7 mm. deep.

Runit: 15 August 1949, *St. John 23,841*. The vernacular name "bop" applies to all *Pandanus*. The holotype was from Palau, Korror, July, 1933, *Nisida 3,348*.

5. *Pandanus odoratissimus* L. f. var. *novocatedonicus* (Martelli) St. John. "Bop." Tree 8 m. × 30 cm.; leaves 130–140 × 9 cm., the midrib below denticulate, the margins denticulate, the teeth towards the tip 1 mm. long, close and fine, towards the base the teeth larger and more remote; phalanges 5.2–5.5 × 3.8 cm., obpyriform, the apex truncate; carpels 3–10, subequal, the apices low convex, the inner sinuses 4–5 mm. deep.

Runit: 15 August 1949, *St. John 23,840*.

6. *Pandanus odoratissimus* L. f. var. *novoguineensis* (Martelli) St. John. "Bop." Tree 7–8 m. × 20 cm.; leaves 115–150 × 5–8 cm., the midrib denticulate below, the margins denticulate, the teeth 1 mm. long and 3–4 per cm. towards the tip, 2 mm. long and more remote towards the base; phalanges 5.2–6 × 3.4–3.6 cm., broad cuneate, the apex low convex; carpels 3–12, usually 7–8, the central ones a little smaller, the apices low convex, the central sinuses 3–4 mm. deep.

Rujoru: 13 August 1949, *St. John 23,811*. Runit: 15 August 1949, *St. John 23,842*. Japtan: 12 September 1957, *Lane 57-136*.

7. *Pandanus pulposus* (Warb.) Martelli. "Jilebar." Tree; leaves 230 × 8 cm., the margins and midrib below armed; fruiting head 33 × 22 cm., ellipsoid, of more than 60 phalanges, these 5–8 × 5–6 cm., broad obpyriform, the apex low dome-shaped; carpels 7–12, the central ones a little smaller, the apices low convex, the central sinuses 3–4 mm. deep.

Aniyaanii: 7 August 1949, *St. John 23,715*. Japtan: 5 February 1955, *Doty 12,779*. Rigili: 11 September 1957, *Lane 57-135;* 10 August 1949, *St. John 23,753*.

8. *Pandanus rectangulatus* Kanehira. "Patchaplip"; "Olivo"; "Desmesyô"; "Anilip"; "Parkup." Tree; leaves 170 × 7 cm., the midrib remotely denticulate below, the margins denticulate, near the tip the teeth 1 mm. long, the teeth about 1 per cm.; fruiting heads 20.5 × 10–15 cm., solitary, pendulous, broad ellipsoid, of 40–45 phalanges, these 6.5 × 5 cm., broad obpyriform, truncate; carpels 5–8, subequal, the apices slightly convex and with a central hollow 0.5–1 mm. deep, the central sinuses 2–3 mm. deep.

Engebi: (as Enchabi I.), the lectotype is September, 1934, *Ohba (Kanehira) 3,469* (Hb. Fukuoka); also nos. *3,473; 3,477;* and *3,479*. Japtan: 6 August 1958, *St. John 26,302*.

9. *Pandanus rhombocarpus* Kanehira. "Papparawa." Tree; fruiting heads 22 × 17 cm., solitary, pendulous, ellipsoid-globose, of more than 77 phalanges, these 7–7.9 × 3.5–4.2 cm., narrow pyriform, the apex subtruncate, with strong lateral sutures running halfway down; carpels 6–8, the central ones much the smaller, the apices subpyramidal, the outer ones distinctly curving salient, the central sinuses 3–6 mm. deep.

Engebi: (as Enchabi I.), holotype, August, 1934, *Ohba (Hosino A.5), (Kanehira 3,467)*.

10. *Pandanus Utiyamai* Kanehira. "Bop." Tree 7 m. × 20 cm.; leaves 160–180 × 6–9.5 cm., swordlike, tapering, the margins closely spine-toothed, near the middle being 1 mm. long and 3 per cm., teeth near the base 2 mm. long and 2 per cm.; fruiting heads 25–26 × 20 cm., ellipsoid-subglobose, solitary, of about 80 phalanges, these 9 × 4.5 cm., obpyriform, with lateral angles, the apex low convex; carpels 8–12, subequal, the apices rounded-subpyramidal, the central sinuses 3–4 mm. deep.

Rujoru: 13 August 1949, *St. John 23,810*. The holotype is from Ponape, August 1933, *Hosino & Utiyama 24 (Kanehira 2,809)*.

GRAMINEAE

11. *Cenchrus Brownii* R. & S. Short-lived plant 30–100 cm. tall, sheaths glabrous; blades 10–30 cm. long, 6–15 mm. wide; racemes 5-12 cm. long, dense; burs depressed globose, the outer bristles numerous, basal, slender; spikelets 4–5 mm. long lanceolate. Introduced weed.

Runit: 24 May 1946, *Taylor 46-1,259;* 15 August 1949, *St. John 23,845*. Eniwetok: 6 August 1949, *St. John 23,711*.

12. *Cenchrus echinatus* L. "Legalek." Plant, 15–75 cm. tall, single or in small tufts; leaf sheaths smooth; blades 7–13 cm. × 3–8 mm., slightly hairy at base; fruiting raceme 3–10 cm. long; spikelets forming burs covered with retrorsely barbed bristles. Introduced weed, abundant and troublesome in disturbed soils.

Engebi: 18 May 1946, *Fosberg 24,378;* 12 August 1949, *St. John 23,783.* Rujoru: observed in 1949, *St. John.* Runit: 24 May 1946, *Taylor 46-1,255;* 15 August 1949, *St. John 23,844.* Japtan: rare, 15 May 1946, *Fosberg 24,324;* May 1946, *Taylor 46-1,289;* observed 1949, *St. John.* Eniwetok: occasional, 13 May 1946, *Fosberg 24,300;* observed, abundant, 1949, *St. John.* Rigili: 1 August 1956, *Rainey.*

13. *Chloris inflata* Link. Slender grass; stems 25–70 cm. tall, erect, erect or often stooling with the base decumbent and rooting at the nodes; sheaths glabrous; cauline blades 6–15 cm. long, 2.5–4 mm. wide, scabrous; the 9–14 spikes digitate, 3.5–9 cm. long; spikelet body 2 mm. long; callus hispid barbate; lemmas with awns 4–6 mm. long; lemma of upper floret globose inflated. Introduced weed.

Engebi: 18 May 1946, *Fosberg 24,407;* 12 August 1949, *St. John 23,784* and *23,782.* Eniwetok: observed 1949, *St. John.*

14. *Cynodon Dactylon* (L.) Pers. Creeping, mat-forming; leaf sheaths smooth; blades 2.5–5 cm. × 2–4 mm.; flowering stems 10–40 cm. tall, smooth; spikes 2–6, digitate, 2–7 cm. long; spikelets 2 mm. long, lanceolate; lemma ciliate on the keel. Deliberately introduced, as lawn grass, and as sand binder.

Eniwetok Atoll: observed 1944, *Bryan.* Engebi: May 1946, *Fosberg 24,397.* Parry: 9 August 1958, *St. John 26,312.* Eniwetok: 13 May 1946, *Fosberg 24,292;* observed 1949, *St. John.*

15. *Dactyloctenium aegyptium* (L.) Aschers. & Schweinf. Short-lived herbaceous grass, 10–30 cm. tall; leaf sheaths glabrous, loose, crowded; blades 3–15 cm. × 2–6 mm., ciliate towards the base; spikes 2–5 cm. long, 2–6 in number, digitate; spikelets 3 mm. long, flat, ovate, acute, 3–5-flowered; glumes scabrous on the keel, the upper one short awned. Introduced weed, by roadside.

Parry: 6 August 1958, *St. John 26,301.*

16. *Digitaria pruriens* (Trin.) Buese. Short-lived grass making small tufts; leaf sheaths pilose; blades 8–15 cm. × 4–13 mm., smooth on both surfaces except at base; stems 30–90 cm. tall; spikes 5–10, digitate, 7–10 cm. long, erect; spikelet 4 mm. long, lanceolate; second glume less than 1 mm. long, hairy on the margins. Introduced weed.

Engebi: observed 1949, *St. John.* Japtan: 27 May 1946, *Taylor 46-1,293.*

17. *Eleusine indica* (L.) Gaertn. Long-lived grass, forming erect clumps; stems 20–100 cm. long; leaf sheaths smooth except at upper margin; blades 15–30 cm. × 4–7 mm., only the upper side with scattered hairs; stalks 30–75 cm. tall; flowering spikes 2–8 digitate or approximate, spreading; spikelets 3–7-flowered, about 6 mm. long, the glumes and lemmas scabrous on the nerves. Introduced weed.

Engebi: observed 1944, *Bryan;* 18 May 1946, *Fosberg 24,384.* Runit: 24 May 1946, *Taylor 46-1,257;* 15 August 1949, *St. John 23,853.* Japtan: 15 May 1946, *Fosberg 24,320;* 27 May 1946, *Taylor 46-1,280.* Parry: 6 August 1958, *St. John 26,300.* Eniwetok: 13 May 1946, *Fosberg 24,289;* observed 1949, *St. John.*

18. *Eragrostis amabilis* (L.) Wight & Arn. "Wujoich." Delicate short-lived grass forming erect tufts 15–30 cm. tall; leaf sheaths glabrous below, long ciliate above; blades 3–9 cm. × 2–4 mm. glabrous; inflorescence a panicle 5–15 cm. long, loose; spikelets 1.5 mm. long, 4–6-flowered; glumes 1 mm. long, lanceolate, the keel hairy. Common, but apparently an introduced weed.

Bogon: 11 August 1949, *St. John 23,772.* Engebi: 18 May 1946, *Fosberg 24,387;* observed 1949, *St. John.* Aomon: 16 May 1946, *Fosberg 24,347;* 4 June 1946, *Taylor 46-1,294;* observed 1949, *St. John.* Biijiri: 14 August 1949, *St. John 23,824.* Runit: 24 May 1946, *Taylor 46-1,256 and 46-1,268.* Parry: in 1957 *Lane 57-104.* Aniyaanii: 25 August 1957, *Lane 57-116.* Japtan: 15 May 1946, *Fosberg 24,344;* 27 May 1946, *Taylor 46-1,294,* observed 1949 *St. John.* Rigili: 10 August 1949, *St. John 23,743;* 1 August 1956, *Rainey;* 11 September 1957, *Lane 57-132.*

19. *Lepturus repens* (Forst. f.) Rr. Br. var. *repens.* "Ujos aitok." Long-lived grass forming clumps in dry places, but trailing runners in wet places; leaf sheaths glabrous or glabrate; blades 5–40 cm. × 2–8 mm., flat or folded, smooth or short hairy, flower spike single, 3–20 cm. long, 1.2–1.5 mm. thick; spikelets 3.5–4 mm. long, 2–3-flowered, awned or not; glumes firm, 5- or more-veined; lemma 3–6 mm. long. The commonest native grass.

Engebi: 18 May 1946, *Fosberg 24,395;* observed 1949, *St. John.* Aitsu: observed 1949, *St. John.* Rujoru: 13 August 1949, *St. John 23,800.* Aomon: 16 May 1946, *Fosberg 24,353;* observed 1949, *St. John.* Biijiri: 14 August 1949, *St. John 23,820.* Runit: 15 August 1949, *St. John 23,854.* Japtan: 15 May 1946, *Fosberg 24,325;* observed 1949, *St. John.* Parry: observed 1944, *Bryan;* 15 May 1946, *Fosberg 24,325.* Parry: observed 1944, *Bryan;* 1957, *Lane 57-102.* Jieroru: 21 May 1946, *Taylor 46-1,241;* Eniwetok: 13 May 1946, *Fosberg 24,298;* observed 1949, *St. John.* Igurin: observed 1949, *St. John;* 6 September 1957, *Lane 57-126.* Mui: 9 August 1958, St. John *26,317.* Rigili: observed 1949 *St. John;* 1 August 1956, *Rainey.*

20. *Lepturus repens* (Forst. f.) R. Br. var. *occidentalis* Fosberg. Differing in having the spikes usually 1.7–2 mm. thick; glumes 10–15 mm. long, acute-acuminate to subulate-acuminate.

Bogon: 31 May 1946, *Taylor 46-1,315;* 11 August 1949, *St. John 23,766.*

21. *Setaria verticillata* (L.) Beauv. Short-lived grass, tufted, erect or decumbent at base, 30–75 cm. tall; leaf sheaths smooth; blades 15–25 cm. × 5–12 mm., flat, scabrous above, spikes 5–7.5 cm. long, erect; spikelet bristles numerous, downward barbed, remaining attached to the axis; spikelets in clusters, 1-flowered, oval, 2 mm. long; outer glume less than half as long as spikelet. Introduced weed, abundant in disturbed soil near settlements.

Engebi: 18 May 1946, *Fosberg 24,392.* Japtan: 27 May 1946, *Taylor 46-1,288;* 15 May 1946, *Fosberg 24,327.* Eniwetok: observed 1949, *St. John.* Eniwetok Atoll: observed August, 1944, *Bryan.*

22. *Sorghum bicolor* (L.) Moench. var. *technicum* (Koern.) Jav. Culm stout 2–4 m. tall; blades up to 1 m. × 8 cm.; panicle 30–80 cm. long, its branches simple for 15–50 cm. and smooth; sessile spikelets 4.5–6 mm. long, obovate-elliptic; upper lemma usually with an awn up to 10 mm. long; grains 3.5–4 mm. long, mahogany red. Cultivated crop grain.

Engebi: May, 1944, observed, *Fosberg.* Runit: 30 May 1946, *Taylor 46-1,305.*

23. *Thuarea involuta* (Forst. f.) R. & S. "Ujos maroro." Perennial, low trailing grass, with long runners; leaf sheaths glabrous or puberulent; blades 3–7 cm. × 4–7 mm., thick, puberulent to glabrate; flower spike, 1-sided, 1–4 cm. long, enclosed in a folded spathe, the axis channeled, puberulent; spikelets 3–4 mm. long, 2-flowered; outer glume 4 mm. long, 5-veined, puberulent. Local, uncommon, found on or near the sea beaches.

Aaraanbiru: 10 April 1954, *Palumbo 1,127.* Aomon: 16 May 1946, *Fosberg 24,354;* observed 1949, *St. John.* Runit: 24 May 1946, *Taylor 46-1,262;* 15 August 1949, *St. John 23,846.* Japtan: 15 May 1946, *Fosberg 24,341;* 12 September 1957, *Lane 57-142;* Eniwetok: 13 May 1946, *Fosberg 24,295.*

24. *Tricachne insularis* (L.) Nees. Clump-forming grass 1–1.5 m. tall; sheaths sparsely hirsute; blades 20–40 cm. long, 8–15 mm. wide; panicle terminal, of racemes 10–15 cm. long; spikelets 4 mm. long, densely silky white villous, in pairs; second glume and sterile lemma 3–5-nerved. Introduced weed.

Japtan: 15 May 1946, *Fosberg 24,328;* observed 1949, *St. John;* 12 September 1957, *Lane 57-138.*

25. *Tricholaena repens* (Willd.) Hitchc. *Rhynchelytrum repens* (Nees) Stapf. & Hubb. ex Bews. Short-lived grass, tufted, 30–60 cm. tall; leaf sheaths sparsely pilose; blades 7–15 cm. long, 3–5 mm. wide, linear, rough on both surfaces and on margins, sparsely pilose; panicle light purplish pink when young; spikelets villous; grain 2 mm. long, elliptic, dark. An introduced weed.

Japtan: 27 May 1946, *Taylor 46-1,296.*

26. *Zea Mays* L. Short-lived, coarse grass, 1–4 m. tall, often with prop roots; leaf sheaths glabrous or puberulent; blades 60–100 × 3–6 cm.; staminate flowers in a terminal tassel, the florets 7–8 mm. long, 2 at each node, 1 of them pedicelled, 2-flowered; pistillate spikelets enwrapped in an ear, with the long styles protruding, the ovaries in 8–24 rows.

Engebi: once cultivated, observed 1944, *Townes.*

CYPERACEAE

27. *Cyperus javanicus* Houtt. "Wujoet in ion buil." *C. pennatus* Lam. Tufted perennial sedge,

30–70 cm. tall; leaves slightly longer than the stem, 5–12 mm. wide, scabrous on margin and midvein; bracts of inflorescence several, unequal, the longest 40–90 cm. long; umbel of 6 or more rays 6–9 cm. long, spikelets 5–13 mm. long, numerous, thick, little compressed; scales 7–12, and 3 mm. long, broadly ovate, reddish brown; achenes 1 mm. long, triangular, dark brown. Probably of aboriginal introduction.

Japtan: 12 September 1957, *Lane 57-145.*

28. *Cyperus odoratus* L. "Ujoet." Coarse, short-lived herb, 15–120 cm. tall; leaves nearly as long, and 2–12 mm. wide, flat; involucral leaves much longer than the rays; umbels simple or compound; spikelets 19–25 mm. long, 5–20-flowered; scales 2–3.5 mm. long; rhachilla disjointing, with wings clasping the achenes, these 1.5–2 mm. long, ellipsoid, triangular, gray to blackish. Introduced weed, wet places.

Japtan: 12 September 1957, *Lane 57-141.*

29. *Fimbristylis atollensis* St. John. "Berelitchman." Densely tufted perennial; stems 25–60 cm. tall, glabrous; leaves all basal, 2–38 cm. × 0.5–2.8 mm., rigid, channeled, the margin serrulate; inflorescence with leafy bracts 5–30 mm. long, the rays 3–8, smooth, 0.2–4 cm. long, simple or branched; spikelets 3–7 mm. long, lance-ovoid, mostly clustered, brown, several flowered; scales 1.2–1.7 mm. long, glabrous; achenes 0.5–0.6 mm. long, turbinate, plano-convex, brown. Native sedge, abundant on most habitats.

Bogombogo: 31 May 1946, *Taylor 46-1,311.* Bogon: 11 August 1949, *St. John 23,771.* Engebi: 21 August 1944, *Bryan.* Aomon: observed 1949, *St. John.* Runit: 15 August 1949, *St. John 23,849.* Aniyaanii: 8 August 1949, *St. John 23,721,* holotype; 25 August 1957, *Lane 57-121.* Japtan: 27 May 1946, *Taylor 46-1,292;* observed 1949, *St. John.* Eniwetok: observed 1949, *St. John.*

PALMAE

30. *Cocos nucifera* L. Unbranched tree, 4–30 m. × 30–70 cm., leaves in terminal plume; stipules 30–60 cm. long, oblong, in age the surface sheds leaving only the fiber mesh; petioles 1–3 m. long, massive; blades 3–6 m. long, pinnate; flowers monoecious, the staminate numerous, the pistillate 6–40; fruit husk mostly 20–40 cm. long, ellipsoid; shell bony, with three basal pores; endosperm white, edible. Once commonly cultivated.

Bogombogo: observed 1946, *Taylor.* Ruchi: observed 1946, *Taylor.* Elugelab: observed 1946, *Taylor.* Teiteiripucchi: observed 1946, *Taylor.* Bogon: observed 1949, *St. John.* Aitsu: observed 1949, *St. John.* Rujoru: observed 1946, *Taylor;* and 1949, *St. John.* Aomon: 14 August 1949, *St. John 23,829.* Biijiri: observed 1949, *St. John.* Aaraanbiru: observed 1946, *Taylor.* Runit: observed 1949, *St. John.* Japtan: observed 1949, *St. John.* Parry: observed 1946, *Taylor.* Eniwetok: observed 1946, *Taylor;* observed 1949, *St. John.* Igurin: 14 May 1946, *Fosberg 24,316;* observed 1946, *Taylor;* observed 1958, *St. John.* Mui: observed 1946, *Taylor.* Rigili: observed 1949, *St. John.*

LILIACEAE

31. *Allium Cepa* L. (?) Perennial herb, 20–60 cm. tall; bulb ovoid to spherical, white, pungent, with odor of onion; leaves 15–50 cm. long, hollow, tubular; scape exceeding the leaves, glaucous; inflorescence an umbel, the buds enclosed in a membranous bract; flowers white or bluish; fruit a small capsule.

As "onions" reported as observed on Eniwetok Islet, in American gardens, in 1944 by *Bryan.*

AMARYLLIDACEAE

32. *Crinum asiaticum* L. (?) Perennial herbs, dividing and forming clumps; from an underground bulb 10–13 cm. in diameter; leaves 20–30, and 0.5–1.5 m. long, 7–10 cm. wide, fleshy, strap-shaped; peduncle 0.5–1.3 m. long; flowers 20–50 in an umbel; pedicels 2.5 cm. long; perianth tube 8–10 cm. long, the segments alike, 6–8 cm. long, strap-shaped, white; capsule green, 2–3 cm. in diameter.

As "spider lily" reported as observed in American gardens on Eniwetok Islet in 1944, by *Bryan.*

TACCACEAE

33. *Tacca Leontopetaloides* (L.) Ktze. "Mokmok." Perennial from white, starchy, poisonous, buried tubers that resemble potatoes, tops annual; a single tuber bearing one leaf and one flower scape; petioles 0.3–1.3 m. tall; blades

0.3–0.7 m. long, 3-parted, then pinnately lobed into strap-shaped segments, horizontal; scape 1–2 m. tall, pale, hollow; flowers in a bracted umbel; perianth 15 mm. long, greenish; berry 20–25 mm. in diameter, globose, finally yellowish. The tubers were grated and washed by the natives to obtain the edible starch. The plant is scarce, probably due to dryness.

Engebi: observed 1949, *St. John*. Rujoru: 13 August 1949, *St. John 23,802;* 4 June 1946, *Taylor 46-1,342*. Biijiri: 14 August 1949, *St. John 23,819*. Japtan: 27 May 1946, *Taylor 46-1,287;* 15 May 1946, *Fosberg 24,333;* observed 1949, *St. John*. Parry: observed 1944, *Bryan*. Igurin: 9 August 1949, *St. John 23,735;* 6 September 1957, *Lane 57-128;* 9 August 1959, *St. John 26,315*.

DICOTYLEDONES

MORACEAE

34. *Artocarpus incisus* (Thunb.) L. f. "Me." Trees 7–25 m. × 0.3–1.5 m., widely branching, with milky sap; leaves alternate; petioles 3–8 cm. long; blades 30–70 cm. long, broadly elliptic, thick, firm, mostly deeply pinnately lobed; staminate flowers in fingerlike spikes 15–30 cm. long; pistillate flowers in stalked green round heads, producing the greenish aggregate fruits 15–30 cm. long, rounded, with or without seeds in the whitish, edible pulp. Of aboriginal cultivation.

Japtan: only 1 tree, 8 m. tall, 7 August 1949, *St. John 23,714;* this had vanished by August 1958, fide *St. John*.

URTICACEAE

35. *Fleurya ruderalis* (Forst. f.) Gaud."Nenkutkut." Roots fibrous; plant glabrous, 10–35 cm. tall; stems fleshy, often becoming reddish; petioles 5–40 mm. long; blades 10–55 mm. long, broadly deltoid ovate, coarsely crenate; peduncles axillary, shorter than the leaves; cymes broad, many flowered; sepals 1.5 mm. long; achenes 1–1.3 mm. long, broad ovoid, compressed, the sides rugose.

Aitsu: 10 March 1954, *Palumbo 1,110*. Engebi: 18 May 1946, *Fosberg 24,399*. Biijiri: 14 August 1949, *St. John 23,817*. Japtan: 15 May 1946, *Fosberg 24,321;* 27 May 1946, *Taylor 46-1,297;* 12 September 1957, *Lane 57-144*. Igurin: 9 August 1958, *St. John 26,313*. Rigili: 1 August 1956, *Rainey*.

OLACACEAE

36. *Ximenia americana* L. "Kalikelik." Shrub to 4 m. tall, sparsely thorny; herbage glabrous; petioles 3–7 mm. long; blades 13–63 mm. long, elliptic, entire; cymes 3–15-flowered, 1–2 cm. long, axillary; petals 6–10 mm. long; drupes 25–30 mm. long, ellipsoid, yellow, the flesh sour, edible.

Rujoru: 2 June 1946, *Taylor 46-1,331;* 13 August 1949, *St. John 23,801*. Japtan: 15 May 1946, *Fosberg 24,319*.

AMARANTHACEAE

37. *Achyranthes aspera* L. "Kaleklek." Short-lived herb, 40–100 cm. tall; stem simple or sparsely branched, appressed hirsute; leaves opposite; petioles 1–3 cm. long; blades 4–12 cm. long, broadly elliptic; spikes terminal 10–25 cm. long, dense; perianth of 3 bracts, the body 2.5 mm. long, the apical spine 2.5 mm. or more long; utricle 2.5 mm. long. Introduced weed.

Aomon: one patch near center, 16 May 1946, *Fosberg 24,348*.

38. *Achyranthes velutina* H. & A. *A. canescens* sensu Taylor Fl. Bikini; non R. Br. Plant herbaceous or at base somewhat woody, 1–3 m. tall, conspicuously hairy; petioles 4–15 mm. long; blades 8–12 cm. long, ovate to lanceolate, acute, cuneate, subappressed villous; spikes 10–25 cm. long, the axis densely white lanate; outer bracts 4–5 mm. long, the base ovate, scarious, the midrib a subulate projecting awn; sepals 5.5–6.5 mm. long, lanceolate; flowers ascending; fruits reflexed.

Giriniien; 20 August 1958, *Lane 57-108*.

39. *Amaranthus dubius* Mart. Herb 20–80 cm. tall, sparsely minutely puberulous, leaves alternate; petioles 3–65 mm. long; blades 3–12 cm. long, ovate, obtuse or acute; inflorescence a terminal panicle of spikes, plus numerous axillary spikes; sepals 1.5–2 mm. long, lanceolate, stiff acuminate; seeds 0.8–1 mm. in diameter, fat discoid, black, shining. Introduced weed.

Eniwetok: 6 August 1949, *St. John 23,702*.

40. *Amaranthus viridis* L. Short-lived herb, erect or prostrate; stem 30–80 cm. long, freely branching; leaves alternate; petioles 2.5–5 cm. long; blades 5–7.5 cm. long, lanceolate to ovate, smooth; flowers monoecious, in terminal spikes and often in axillary clusters; sepals nearly 1 mm. long, lanceolate; ovary wrinkled, and in fruit indehiscent; seeds less than 2 mm. wide, discoid, brown. Introduced weed.

Parry: 20 August 1944, *Bryan.*

NYCTAGINACEAE

41. *Boerhavia diffusa* L. var. *diffusa.* "Matok aitok." "Rebijraka." Trailing perennial herb, from fleshy root; branches 30–200 cm. long, often pink; leaves opposite; petioles 4–10 mm. long; blades 2.5–4 cm. long, ovate to ovate-lanceolate, variable; upright branchlets with reduced leaves; peduncles 2–8 cm. long; inflorescence umbellate-paniculate, with heads of pink flowers; calyx tube 3 mm. long, funnelform, glandular; stamens 2–3; nutlet 3 mm. long, fusiform, viscid hairy. Abundant.

Engebi: 18 May 1946, *Fosberg 24,394;* 12 August 1949, *St. John 23,779.* Aomon: 16 May 1946, *Fosberg 24,356,* and *24,362.* Aaraanbiru: 3 June 1946, *Taylor 46-1,337.* Aniyaanii: 8 August 1949, *St. John 23,718;* 1957, *Lane 57-120.* Japtan: 20 August 1944, *Bryan;* 27 May 1946, *Taylor 46-1,295.* Eniwetok: 6 August 1949, *St. John 23,709.* Igurin: 14 May 1946, *Fosberg 24,306;* 6 September 1957, Lane *37-123.* Rigili: 1 August 1956, *Rainey.*

42. *B. diffusa* var. *tetrandra* (Forst. f.) Heimerl. "Rabitchragai." Calyx tube glabrous; stamens 3–6.

Bogombogo: 31 May 1946, *Taylor 46-1,307.* Bogon: 11 August 1949, *St. John 23,761.* Rujoru: 13 August 1949, *St. John 23,806.* Aomon: 4 June 1946, *Taylor 46-1,350.* Aaraanbiru: 3 June 1946, *Taylor 46-1,335.* Runit: 24 May 1946, *Taylor 46-1,263.* Aniyaanii: 25 May 1946, *Taylor 46-1,274.* Igurin: 22 May 1946, *Taylor 46-1,250.* Rigili: 10 August 1949, *St. John 23,747;* 1 August 1956, *Rainey;* 11 September 1957, *Lane 57-131,* and *57-133.*

43. *Mirabilis Jalapa* L. "Emen aur." Herb 0.3–1 meter tall, glabrous, freely wide branching; leaves opposite; petioles 1–2.5 cm. long; blades 5–10 cm. long, ovate, the base truncate or cordate; involucre green; calyx 5–7 cm. long, wide funnelform, petaloid, in several colors; fruit leathery, ribbed; seeds 6 mm. in diameter, blackish. Introduced, probably as an ornamental.

Eniwetok: 17 May 1946, *Fosberg 24,370.*

44. *Pisonia grandis* R. Br. "Kangae." Tree, 5–20 m. tall; wood soft; leaves subopposite or crowded, nearly glabrous; petioles 1–4 cm. long; blades 8–20 cm. long, elliptic, the apex and base commonly acute; cymes terminal, more or less puberulent; flowers unisexual; calyx 4–6 mm. long, campanulate, pink; fruit 1 cm. long, fusiform, with several longitudinal, glandular spiny ribs. Abundant, forming forests on better habitats.

Elugelab: 2 June 1946, *Taylor 46-1,251.* Bogon: 11 August 1949, *St. John 23,769. Engebi:* 18 May 1946, *Fosberg 24,402.* Aitsu: 13 August 1949, *St. John 23,795.* Rujoru: 2 June 1946, *Taylor 46-1,325;* 13 August 1949, *St. John 23,807.* Aomon: 16 May 1946, *Fosberg 24,357;* 4 June 1946, *Taylor 46-1,352.* Biijiri: 14 August 1949, *St. John 23,816.* Aaranbiru: 3 June 1946, *Taylor 46-1,335.* Runit: 24 May 1946, *Taylor 46-1,265;* 15 August 1949, *St. John 23,839.* Aniyaanii: 25 May 1946, *Taylor 46-1,272;* 8 August 1949, *St. John 23,726.* Japtan: 15 May 1946, *Fosberg 24,332* and *24,337;* observed 1946, *Taylor;* 1957, *Lane 57-147.* Parry: observed 1944, *Bryan.* Jieroru: 21 May 1946, *Taylor 46-1,245.* Igurin: 14 May 1946, *Fosberg 24,304,* and *24,308;* 22 May 1946, *Taylor 46-1,251;* 9 August 1949, *St. John 23,736.* Giriinien: 20 August 1957, *Lane 57-107,* and *57-109.* Rigili: 10 August 1949, *St. John 23,744.*

PORTULACACEAE

45. *Portulaca lutea* Soland. "Kiran." Fleshy, long-lived herb, prostrate or suberect, glabrous; stems 15–50 cm. long, enlarging and becoming suffrutescent at base; petioles 1–3 mm. long, with tuft of axillary hairs; blades 10–35 mm. long; petals when fresh 10–12 mm. long, yellow; stamens 24–48; seeds 1–1.1 mm. long, black.

Bogombogo: 31 May 1945, *Taylor 1,312.* Bogon: 11 August 1949, *St. John 23,762.* Aitsu: observed 1949, *St. John.* Aomon: 16 May 1946,

Fosberg 24,358; 4 June 1946, *Taylor 46-1,344.* Aniyaanii: 8 August 1949, *St. John 23,728.* Japtan: 15 May 1946, *Fosberg 24,326.* Jieroru: 21 May 1946, *Taylor 46-1,242.* Igurin: 9 August 1949, *St. John 23,738.* Rigili: 10 August 1949, *St. John 23,749.*

46. *Portulaca oleracea* L. Fleshy herb, prostrate or ascending, glabrous, stems 5–40 cm. long; petioles 1–3 mm. long, with tufts of white axillary hairs; blades 12–25 mm. long, cuneate or cuneate-obovate; petals when fresh 2–4 mm. long; stamens 7–15; seeds 0.7 mm. long, black.

Engebi: 18 May 1946, *Fosberg 24,408;* 12 August 1949, *St. John 23,785* and *23,786.* Aitsu: observed 1949, *St. John.* Rujoru: observed 1949, *St. John.* Aomon: 14 August 1949, *St. John 23,834.* Runit: 15 August 1949, *St. John 23,850.* Eniwetok: 13 May 1946, *Fosberg 24,296;* observed 1949, *St. John.*

47. *Portulaca samoensis* v. Poelln.; *P. quadrifida* sensu Kanehira, non L. "Bujon." Perennial, semiprostrate, fleshy herb, forming dense mats; stems 10–20 cm. long; leaves alternate, but at the stem apices much crowded; axillary hairs 4 mm. long, white, abundant; leaves 5–8 mm. long; petals yellow; capsule 3.5 mm. long, thin walled; seeds 0.5 mm. in diameter, reniform, black, rugose.

Aomon: 14 August 1949, *St. John 23,830.* Runit: 24 May 1946, *Taylor 1,258.* 15 August 1949, *St. John 23,851.* Aniyaanii: 8 August 1949, *St. John 23,719;* 25 August 1957, *Lane 57-115.*

LAURACEAE

48. *Cassytha filiformis* L. "Kenen." Parasitic, entwining herb; stems of great length, 1–3 mm. diameter, green, becoming yellowish; leaves reduced to tiny, alternate, ciliate scales; flower spikes 2.5–5 cm. long; calyx in 2 series, the 3 outer minute, the 3 inner 3 mm. long, white; drupe 6–7 mm. diam., globose, firm, cream-colored.

Elugelab: 2 June 1946, *Taylor 46-1,321.* Bogon: 11 August 1949, *St. John 23,770.* Engebi: observed 1949, *St. John.* Aitsu: observed 1949, *St. John.* Rujoru: 2 June 1946, *Taylor 1,330;* 13 August 1949, *St. John 23,803.* Aomon: 4 June 1946, *Taylor 46-1,347;* 16 May 1946, *Fosberg 23,803.* Runit: 24 May 1946, *Taylor 1,253;* 15 August 1949, *St. John 23,838.* Aniyaanii: 25 May 1946, *Taylor 46-1,277.* Japtan: 15 May 1946, *Fosberg 24,330.* Parry: observed 1944, *Bryan.* Eniwetok: 13 May 1946, *Fosberg 24,288;* observed 1949, *St. John.* Igurin: 14 May 1946, *Fosberg 24,313;* observed 1949, *St. John.* Giriinien: 23 August 1957, *Lane 57-110.* Rigili: 10 August 1949, *St. John 23,746.*

HERNANDIACEAE

48a. *Hernandia sonora* L. "Bingbing." Tree up to 15 m. tall, 20–40 cm. in diameter; leaves alternate, glabrous; petiole 10–13 cm. long; blades 12–20 cm. long, 8–16 cm. wide, broadly ovate, acute, peltate well in from the margin, palmately nerved; panicles 10–30 cm. long; flowers unisexual; flowers in 3's, 1 pistillate and 2 staminate in an involucre of 4 velvety bracts; staminate flowers with 3 sepals 5 mm. long, short hairy; 3 petals hairy; pistillate flowers each surrounded by a cuplike involucre; three sepals 4 mm. long; petals 3, closely hairy; ovary 1-celled, inferior; fruit an achene 25 mm. long, ellipsoid, brown, loosely enclosed by the greenish, fleshy involucre with its apical circular aperture.

Eniwetok: 1958, *Palumbo.* Fruits found in jetsam on sea beaches, not known growing on the island. However, it is indigenous and common on other Marshall islands, the nearest localities being on Ujelang, Kwajalein, Wotje, and Likiep. The specimens were determined by F. R. Fosberg.

CRUCIFERAE

49. *Brassica oleracea* L. *capitata.* Annual or biennial herb, in the first year forming a dense, headlike rosette; leaves sessile 15–35 cm. long, suborbicular, fleshy, with a sharp taste; later producing an upright leafy stem; racemes loose; petals yellow; capsule 5–10 cm. long, with a conical beak. Cultivated vegetable.

Eniwetok: observed 1944, as "cabbage" in American gardens, *Bryan.*

50. *Brassica pekinensis* (Lour.) Rupr. Annual herb forming close rosette, nearly glabrous; basal leaves 30–60 cm. long, oblong-obovate, thin, undulate, mild in taste; petiole flat, auriculate-winged; flowers crowded at tip of raceme; petals 1 cm. long, light yellow; capsule

3–6 cm. long, stout. Cultivated vegetable.

Engebi: in old garden, May 1944, *Fosberg.*

51. *Brassica* sp. (?)

Engebi: "two hardy, although somewhat wilted members of the cabbage family," observed 1944, *Bryan.*

52. *Raphanus sativus* L. Annual or biennial; root enlarged, peppery, edible; stem 60–100 cm. tall, glaucous; leaves lyrate; racemes loose; petals 15 mm. long, white to purplish; capsule 2.5–7.5 cm. long, beaked. Cultivated vegetable.

Eniwetok: in American gardens, observed as "radish" in 1944, *Bryan.*

LEGUMINOSAE

52a. *Caesalpinia Bonduc* (L.) Roxb. Large, sturdy vine, often 10 m. long; stems thorny; stipules none; leaves bipinnate, the leaflets in 4–8 pairs on each pinna, 3–5 cm. long, broadly elliptic, the petioles and rhachises prickly; sepals 7–8 mm. long, oval; petals yellow, 2–3 times as long as the sepals; pods about 7 cm. long, oval, compressed, prickly; the 2–3 seeds 14 mm. in diameter, globose, gray.

Eniwetok Atoll: 1946, *St. John 22,197*; 1958, *Palumbo.* Found only as drift seeds on the beaches. They could have come from the northeast, the south, or the west.

53. *Canavalia microcarpa* (DC.) Piper; *C. turgida* Graham ex Miq. "Marlap." Biennial, herbaceous vine; stems glabrous; leaves trifoliolate; petiole 6–15 cm. long; leaflets 6–10 cm. long, oval, acuminate, abruptly obtuse at base, almost glabrous; peduncle 15–25 cm. long; pedicels 2 mm. long; calyx 12 mm. long, sparsely villous; petals 20–25 mm. long, rose-colored; pod 9–12 × 3.5 cm.; seeds 18 × 12 mm., compressed, brown.

Eniwetok: 6 August 1949, *St. John 23,707.* Igurin: 14 May 1946, *Fosberg 24,309*; 9 August 1949, *St. John 23,739*, and *26,316.*

53a. *Dioclea reflexa* Hook. f. Woody vine; petioles 7.2–9.6 cm. long, pilose; leaflets 3, terminal leaflet 13.2–16 cm. long, broad elliptic, subacuminate, firm, below sparsely villous on veins; peduncle 10–33 cm. long; floral bracts prominent, 9–12 mm. long; calyx 12–14 mm. long, cupulate, hirsutulous; corolla reddish purple, the banner 17–21 mm. long, suborbicular; pod 11–14.5 × 5.8–6.6 cm. × 9 mm., oval; seeds 27–29 × 21–26 × 12–17.5 mm., reddish to brownish.

Found rarely as seeds only, in the drift on the beaches. Collected in 1946, *St. John 22,007*; and about 1953 by *Donaldson.* It probably came from the west or south.

54. *Entada phaseoloides* (L.) Merr. Woody vine of great size, stems up to 75 m. in length, somewhat flattened and up to 15 cm. in width, containing potable water; leaves bipinnate; stipules 4 mm. long, hornlike, caducous; petioles 10–25 cm. long, ending in a 2-parted tendril; leaflets 4–6 cm. long, 2–3 cm. wide, oblong or lanceolate; flowers subsessile in spikes; petals 2.5 mm. long, narrowly oblong; pod 45–60 cm. long, 5–7 cm. wide, massive, contracted around the seeds; seeds discoid, shining, brown, hard.

Eniwetok: 1958, *Palumbo* no. *D.* Known here only as seeds in the sea drift. Not indigenous to the Marshalls, but probably drifting from islands to the south or west.

55. *Mucuna urens* (L.) Medic. Climbing vine; leaves alternate, 3-foliolate; petioles 6–12 cm. long; terminal leaflet 7.5–16 cm. long, lanceovate to obovate, acuminate; inflorescence 30–90 cm. long, many flowered; calyx 11–13 mm. long, campanulate, sericeous and hispid; corolla 35 mm. long; pods 15–25 cm. long, oblong, 4–4.5 cm. wide, densely hispid with irritating hairs; seeds 3 cm. broad, discoid, flattened but fat, brown, surrounded by the hilum.

An exotic, not found growing, but as drift seeds on beach of Engebi, 1949, *St. John.* It surely drifted from Hawaii on the northeast.

56. *Phaseolus vulgaris* L. Annual vines, erect or twining, pubescent; the three leaflets 10–15 cm. long, rhombic-ovate, acuminate; racemes few-flowered; petals 12–22 mm. long, white to purple; pod 10–20 cm. long, terete or compressed, edible. Cultivated vegetable.

Eniwetok: in American gardens, as "string beans," observed 1944, *Bryan.*

57. *Phaseolus* sp. (?)

Eniwetok: in American gardens, as "beans," observed 1944, *Bryan.*

58. *Vigna marina* (Burm.) Merr. "Markinejojo." Trailing perennial vine; stems 15–100 cm. long; the three leaflets 5–8 cm. long, obovate to suborbicular, somewhat fleshy, sparsely

appressed pilose when young; flowers in racemes; corolla 10–14 mm. long, bright yellow; legume 5–7 cm. long, the valves twisting after opening. Seeds 6–8 mm. long.

Parry: observed 1944, *Bryan*.

ZYGOPHYLLACEAE

59. *Tribulus cistoides* L. Erect perennial herb, forming clumps, hirsute; stipules 4–7 mm. long; leaves opposite, even pinnate with 8 pairs of leaflets, these 12–16 mm. long, oblong-elliptic, white appressed sericeous; flowers solitary; sepals 6 mm. long; petals 2–2.5 cm. long, obovate, bright yellow; fruit splitting into 5-6 wedge shaped cocci, each with 2 strong dorsal horns.

Engebi: 15 May 1946, *Fosberg 24,403*.

SIMAROUBACEAE

60. *Suriana maritima* L. "Ngiungi." Shrub 1-3 m. tall; leaves 1–2 cm. long, linear spatulate, alternate but crowded, closely appressed pilose; racemes subterminal; calyx lobes lance-deltoid; petals 7–9 mm. long, yellow, the 5 carpels free; capsules 1-seeded.

Bogombogo: 31 May 1946, *Taylor 46-1,306*. Bogon: 11 August 1949, *St. John 23,765*. Rujoru: 2 June 1946, *Taylor 46-1,324;* 13 August 1949, *St. John 23,809*. Aomon: 4 June 1946, *Taylor 46-1,343;* observed 1949, *St. John*. Igurin: 14 May 1946, *Fosberg 24,310;* 9 August 1949, *St. John 23,734*. Giriinien: 28 May 1946, *Taylor 46-1,303;* 23 August 1957, *Lane 57-112*. Rigili: 10 August 1949, *St. John 23,752*.

EUPHORBIACEAE

60a. *Aleurites moluccana* L. Tree 12–25 m. tall, 25–100 cm. in diameter; bark gray; sap a blood coagulant; leaves alternate, the young ones concealed by appressed pubescence and from a distance appearing white; petioles 4–15 cm. long, stellate pubescent or farinose; blades strikingly polymorphic, narrow or broad, entire or lobed, with a lateral lobe on each side, or only on the right side, or only on the left side, 8–20 cm. long, 4–10 cm. wide, stellate pubescent to subglabrate; panicles 10–15 cm. long, pubescent; flowers unisexual, the pistillate few; staminate flowers with calyx 3–4 mm. long, ovoid, 2–3-lobed; petals 5–9 mm. long, oblong, white; stamens 12 or more; pistillate flowers with calyx 6 mm. long; nut mostly 1-seeded and globose, the husk 5 cm. in diameter, green, then wrinkled and brownish, separating after decaying; stone 2.5–3 cm. long, subovoid, resembling an English Walnut; seed oily, cathartic, but after roasting edible and tasty.

Eniwetok: 1958, *P.alumbo*. Found only as a single husked stone in the sea drift. It arrived by flotation, but could have come from the northeast, as Hawaii, or from the south, or from the west.

61. *Euphorbia Chamissonis* (Klotsch & Garcke) Boiss. "Berol." Glabrous perennial herb, forming clumps 20–30 cm. tall; leaves 2 cm. long, entire, obovate, obtuse or retuse, subcordate, glaucous below; cymes terminal; involucre turbinate, the ovate-triangular teeth hirsute, the glands white, entire or lobed; seeds ovate-quadrangular, subrugose tuberculate.

Bogon: 11 August 1949, *St. John 23,767*. Engebi: 18 May 1946, *Fosberg 24,385*. Eniwetok: 10 September 1957, *Lane 57-129*.

62. *Euphorbia hirta* L. Short-lived herb, often branching near the base, the tips ascending, 15–30 cm. tall, densely hirsute; petioles 2 mm. long; blades 2–4 cm. long, elliptic-oblong to oblong-lanceolate, serrate; inflorescences axillary, capitate, greenish to purplish; involucre 1 mm. long, puberulent; capsule long stalked, 1.5 mm. diam.; seeds 0.5 mm. long, oblong, brown. Introduced weed.

Japtan: 12 September 1957, *Lane 57-146*. Eniwetok: 17 May 1946, *Fosberg 24,367*.

63. *Euphorbia thymifolia* L. Short-lived herb, stems 10–30 cm. long, prostrate, densely hirsute; leaves opposite; petioles 2 mm. long; blades 2–4 cm. long, ovate-elliptic, oblique, acute, serrulate; flowers in dense axillary cymes; involucres 1 mm. long; capsule 1.5 mm. diam., puberulent; seeds reddish brown, rugulose. Introduced weed.

Japtan: 12 September 1957, *Lane 57-143*. Eniwetok: 10 September 1957, *Lane 57-130*.

64. *Phyllanthus amarus* Schum. & Thonn. *P. niruri* auth. in part, not of L. Erect, short-lived herb, 1–5 dm. tall; internodes 1–3 cm. long; stipules 0.8–1.3 mm. long, broadly ovate-lanceolate or lanceolate; petioles 0.3–0.5 mm. long; blades mostly 5–11 mm. long, elliptic-oblong, obtuse or apiculate; staminate flowers with

calyx lobes 0.3–0.6 mm. long; pistillate flowers on pedicels 0.6–0.7 mm. long, becoming 1–2 mm. long; the calyx lobes 0.9–1.1 mm. long, whitish scarious margined; capsule 1.9–2.1 mm. diam., oblate, trigonous; seeds 0.9–1 mm. long, trigonous, light brown, 5–6-ribbed on the back. Weed, introduced from America.

Japtan: observed 1949, *St. John.* Parry: 20 August 1957, *Lane 57-105.* Eniwetok: 6 August 1949, *St. John 23,706.*

65. *Ricinus communis* L. Shrub or tree up to 9 m. tall; leaves alternate; flowers monoecious in terminal racemes; staminate flowers with 3–5-parted calyx, and numerous stamens with branched filaments; pistillate flowers higher up with deciduous calyx; capsule rounded, 3-lobed, spiny; seeds 7–15 mm. long, ellipsoid, mottled. Introduced ornamental.

Engebi: 18 May 1946, *Fosberg 24,377.* Eniwetok: 6 August 1949, *St. John 23,701.*

SAPINDACEAE

65a. *Sapindus Saponaria* L. Tree 5–10 m. tall; bark gray, rough; leaves alternate, without stipules, odd pinnate, 20–50 cm. long; petiole and rhachis commonly winged; leaflets mostly 7–9 and 5–15 cm. long, elliptic to oblong-lanceolate, obtuse or acute, often falcate; panicles 17–27 cm. long, pubescent; sepals 1.5 mm. long, pubescent; petals 2.5 mm. long, elliptic, white, ciliate; berry nearly 2 cm. in diameter, brown, the flesh translucent, orange brown; seed bony, black.

Eniwetok Atoll: 1958, *Palumbo.* Found rarely as seeds in drift on sea beaches, not indigenous in Marshall Is. Probably the seeds drifted from Hawaii, that is from the northeast. Specimens determined by F. R. Fosberg.

TILIACEAE

66. *Triumfetta procumbens* Forst. f. "Adat." Perennial, trailing suffrutescent vine, generally stellate hirsutulous; petioles 2–4 cm. long; blades 3–10 cm. long, suborbicular but the base rounded or cordate, the apex with 3 large, rounded lobes, the texture firm, above green and smooth; cymes axillary; 5 sepals 1 cm. long, linear-oblong; petals 1 cm. long, yellow; capsules 12 mm. in diameter. The stem has a band of excellent white fiber, much used in weaving.

Bogombogo: 31 May 1946, *Taylor 46-1,313.* Bogon: 31 May 1946, *Taylor 46-1,316;* 11 August 1949, *St. John 23,768.* Engebi: observed 1944, *Bryan;* 18 May 1946, *Fosberg 24,401;* observed 1949, *St. John.* Aitsu: 13 August 1949, *St. John 23,792.* Rujoru: 13 August 1949, *St. John 23,804.* Aomon: 16 May 1946, *Fosberg 24,366;* 4 June 1946, *Taylor 46-1,351;* observed 1949, *St. John.* Biijiri: 14 August 1949, *St. John 23,818;* Runit: 24 May 1946, *Taylor 46-1266B;* 15 August 1949, *St. John 23,848.* Aniyaanii: 25 May 1946, *Taylor 46-1,275;* 25 August 1957, *Lane 57-118.* Japtan: 15 May 1946, *Fosberg 24,322.* Parry: observed 1944 *Bryan.* Jieroru: 21 May 1946, *Taylor 46-1,248.* Eniwetok: 13 May 1946, *Fosberg 24,299;* observed 1949, *St. John.* Igurin: 14 May 1946, *Fosberg 24,311;* observed 1949, *St. John.* Mui: 9 August 1958, *St. John 26,318.* Rigili: 10 August 1949, *St. John 23,754;* 1 August 1956, *Rainey.*

MALVACEAE

67. *Malvastrum coromandelianum* (L.) Garcke. Long-lived herb, 0.3–1 m. tall, sparsely hirsute; petioles 6–18 mm. long; blades 2.5–5 cm. long, lanceolate to ovate, sparsely appressed hirsute, the margin serrate; flowers axillary; pedicels 4–6 mm. long; calyx 3-bracted, 6–9 mm. long; petals orange-yellow, a little longer; carpels borne in a ring, each 3-spined; seed 2 mm. wide, cordate brown. Introduced weed.

Parry: 16 August 1957, *Lane 57-103.*

68. *Sida fallax* Walp. "Kio." Shrub 0.3–1.5 m. tall, with many lateral, slightly ascending branches; stipules subulate; petioles 7–12 mm. long; blades 2.5–3.3 cm. long, ovate to elliptic, crenate, hoary on both sides; calyx 6 mm. long, closely stellate hoary, funnelform, lobed half way, the tube 10-ribbed; petals 10–12 mm. long, orange-yellow; fruit separating into several cocci 3–3.6 mm. long, wedge-shaped, the back rugose, the apex opening by 2 rounded oblique valves.

Eleugelab: 2 June 1946, *Taylor 46-1,318.* Engebi: 21 August 1944, *Bryan;* May 1946, *Fosberg & Hosaka 24,389;* 18 May 1946, *Fosberg 24,393;* observed 1949, *St. John.* Aitsu: 13 August 1949, *St. John 23,794.* Rujoru: 2 June 1946, *Taylor 46-1,329;* 13 August 1949, *St. John*

23,808. Aomon: 16 May 1946, *Fosberg 24,359;* 4 June 1946, *Taylor 46-1,348;* 14 August 1949, *St. John 23,832,* and *23,833*. Parry: 20 August 1944, *Bryan*. Eniwetok: 17 May 1946, *Fosberg 24,371;* observed 1949, *St. John*. Igurin: 9 August 1958, *St. John 26,314*. Rigili: 1946, *Morrison* (*Taylor 46-1,281*); 10 August 1949, *St. John 23,750;* 1 August 1956, *Rainey;* 11 September 1957, *Lane 57-134*.

CARICACEAE

69. *Carica Papaya* L. "Keinapu." Columnar trees 3–15 m. tall, with soft trunk and milky sap; leaves in terminal wide spreading plume; petioles 20–70 cm. long, hollow; blades 40–110 cm. long, circular in outline, deeply 7-lobed then pinnatifid; flowers usually dioecious; staminate flowers borne in pendent racemes, numerous, white, 2.5 cm. long, the tube slender, elongate; pistillate flowers axillary, subsessile, 2.5 cm. long, creamy white, with 5 distinct petals; fruit 8–40 cm. long, ellipsoid to globose, the pulp edible; seeds 2 mm. long, black. Recently introduced fruit tree.

Parry: observed 1958, *St. John*.

LYTHRACEAE

70. *Pemphis acidula* J. R. & G. Forst. "Kungi." Shrub or rarely tree up to 11 m. tall; the wood hard and tough; leaves opposite, subsessile, 10–32 mm. long, lanceolate to oval, obtuse or acute, appressed sericeous; flowers single in axils; calyx 6-lobed, hairy; petals 4–6 mm. long, obovate; seeds 3 mm. long, cuneate.

Bogon: 11 August 1949, *St. John 23,774*. Aniyaanii: 25 May 1946, *Taylor 46-1,276;* 8 August 1949, *St. John 23,727;* Giriinien: 1957, *Lane 57-106*.

RHIZOPHORACEAE

71. *Rhizophora Mangle* L. Tree to 25 m. tall, glabrous; petioles 10–25 mm. long; blades 5–15 cm. long, elliptic, leathery, blunt or notched; cymes 3–4 cm. long; calyx and corolla 1 cm. long; 4 petals lanceolate, yellow, pilose within; capsule 2.5 cm. long. Introduced tree, restricted to tidal salty shores.

Bogombogo: February 1954, planted by *Palumbo*.

COMBRETACEAE

72. *Terminalia samoensis* Rechinger. "Kugung." *T. litoralis* sensu Taylor, Fl. Bikini, non Seem. Tree up to 8 m. × 30 cm.; stems and petioles tawny appressed puberulent; leaves alternate; petioles 1–3 cm. long; blades 6–15 cm. long, broadly obovate, obtuse or subacute; inflorescences 3–10 cm. long, axillary, puberulent; flower 7 mm. long, urceolate, the tube hirsutulous without; drupes 15–18 mm. long, ellipsoid, compressed, red.

Elugelab: 2 June 1946, *Taylor 46-1,317*. Aitsu: 13 August 1949, *St. John 23,797*. Rujoru: 2 June 1946, *Taylor 46-1,323*. Aomon: 4 June 1946, *Taylor 46-1,341*. Aniyaanii: 25 May 1946, *Taylor 46-1,273;* 13 September 1957, *Lane 57-148*. Japtan: 15 May 1946, *Fosberg 24,331;* 27 May 1946, *Taylor 46-1,285*. Jieroru: 21 May 1946, *Taylor 46-1,243*. Mui: 28 May 1946, *Taylor 46-1,301*. Giriinien: 23 August 1957, *Lane 57-111*. Rigili: 10 August 1949, *St. John 23,741;* 1 August 1956, *Rainey*.

APOCYNACEAE

73. *Ochrosia oppositifolia* (Lam.) K. Schum. "Kijebar." Tree up to 15 m. × 90 cm.; leaves glabrous; petioles 3–5 cm. long; blades 10–35 cm. long, elliptic to obovate-elliptic, firm; cymes 7–10 cm. long; calyx 4–5 mm. long; corolla white, the tube 6 mm. long, the 5 lobes 7–8 mm. long, obtuse; fruits 6 cm. long, twinned, ellipsoid, red, 2-seeded; mesocarp with many longitudinal fibers. Tissues poisonous.

Japtan: 15 May 1946, *Fosberg 24,329;* 27 May 1946, *Taylor 46-1,291;* observed 1949, *St. John*. Igurin: 6 September 1957, *Lane 57-124*.

CONVOLVULACEAE

74. *Ipomoea pes-caprae* (L.) Sweet, subsp. *brasiliensis* (L.) v. Ooststr. "Marginejojo." Perennial, glabrous vine; branches trailing, up to 10 m. long; petioles 5–20 cm. long; blades 3–12.5 cm. long, thick, ovate to obovate to suborbicular, commonly emarginate, rarely obtuse or acute and mucronulate; cymes 3–10 cm long, 1–20-flowered; sepals unequal, the outer 5–13 mm. long, the inner 7–16 mm. long; corolla 3–7 cm. long, short broad funnelform; capsules 13–19 mm. in diameter; seeds 7–9 mm.

long, spherical, brown villous.

Engebi: 18 May 1946, *Fosberg 24,404;* 12 August 1949, *St. John 23,778.* Aomon: 14 August 1949, *St. John 23,831.* Eniwetok: 13 May 1946, *Fosberg 24,287;* observed 1949, *St. John.* Igurin: 9 August 1949, *St. John 23,733.*

75. *Ipomoea purpurea* (L.) Roth. Short-lived, twining climber; stems 1–3.3 m. long, retrorse pilose; petioles 7–13 cm. long; blades 7–13 cm. long, acute; peduncles 1–5-flowered, sepals 12–16 mm. long, lanceolate, hirsute at base; corolla 4.5–7 cm. long, narrow funnelform; capsule 1 cm. diameter. Cultivated ornamental.

Engebi: observed May 1949, *Townes.*

76. *Ipomoea tuba* (Schlecht.) G. Don. "Marbele." *I. alba.* sensu Taylor, Fl. Bikini. Perennial glabrous vine, trailing or climbing; stems to 8 m. long; petioles 4–8 cm. long; blades 7–15 cm. long, broadly ovate, deeply cordate, soft and a little fleshy; peduncles 2–10 cm. long, usually 1-flowered; sepals elliptic, 2 cm. long, subequal; corolla 5–8 cm. long, trumpet-shaped; capsule 15 mm. long, subglobose; seeds villous on angles and by hilum, puberulent elsewhere.

Engebi: 12 August 1949, *St. John 23,781.* Aitsu and Rujoru: observed 1949, *St. John.* Aomon: 4 June 1946, *Taylor 46-1,346;* observed 1949, *St. John.* Biijiri: 14 August 1949, *St. John 23,825.* Runit: observed 1949, *St. John.* Aniyaanii: 8 August 1949, *St. John 23,720;* 25 August 1957, *Lane 57-119.* Japtan: 27 May 1946, *Taylor 46-1,290;* observed 1949, *St. John.* Jieroru: 25 May 1946, *Taylor 46-1,239.* Eniwetok and Igurin: observed 1949, *St. John.*

BORAGINACEAE

77. *Cordia subcordata* Lam. "Kono." Tree, 7–16 m. tall; wood brown, hard; petioles 2–6 cm. long; blades 12–15 cm. long, ovate to subcordate, firm, nearly glabrous except for hairy tufts in vein axils below; cymes shorter than petioles; calyx 10–15 mm. long, urceolate, irregularly 3–5-lobed; corolla broad funnelform; drupe 10–30 mm. long, bony.

Aitsu: 13 August 1949, *St. John 23,796.* Aomon: 16 May 1946, *Fosberg 24,351;* 4 June 1946, *Taylor 46-1,346.* Aaraanbiru: 3 June 1946, *Taylor 46-1,338.* Runit: 24 May 1946, *Taylor 46-1,267.* Aniyaanii: 25 May 1946, *Taylor 46-1,270;* 8 August 1949, *St. John 23,725;* and 23 August 1957, *Lane 57-112,* and *57-148.* Japtan: observed 1944, *Bryan;* 15 May 1946, *Fosberg 24,338;* 27 May 1946, *Taylor 46-1,290.* Jieroru: 25 May 1946, *Taylor 46-1,239.* Igurin: 14 May 1946, *Fosberg 24,303;* 9 August 1949, *St. John 23,737.* Rigili: 10 August 1949, *St. John 23,742.*

78. *Messerschmidia argentea* (L. f.) Johnst. "Kirin." Tree to 10 m. × 45 cm.; herbage appressed sericeous; leaves in terminal plumes; petioles 5–10 cm. long; blades 8–20 cm. long, oblanceolate, thick, fleshy; cymes 10–25 cm. long, terminal, many-flowered; berries 3–7 mm. diameter, white. Here often shrublike.

Bogombogo: 31 May 1946, *Taylor 46-1,309.* Ruchi: observed 1949, *Taylor.* Elugelab: observed 1949, *Taylor.* Bogon: 11 August 1949, *St. John 23,763.* Engebi: 18 May 1946, *Fosberg 24,396;* observed 1949, *St. John.* Aitsu: 13 August 1949, *St. John 23,791.* Rujoru: 2 June 1946, *Taylor 46-1,326;* 13 August 1949, *St. John 23,805.* Aomon: 14 May 1946, *Fosberg 24,352;* observed 1949, *St. John.* Biijiri: 14 August 1949, *St. John 23,821.* Runit: 24 May 1946, *Taylor 46-1,264;* 15 August 1949, *St. John 23,852.* Aniyaanii: 25 May 1946, *Taylor 46-1,279;* 8 August 1949, *St. John 23,724.* Chinimi: observed 1946, *Taylor.* Japtan: 15 May 1946, *Fosberg 24,339;* observed 1949, *St. John.* Parry: observed 1944, *Bryan;* and 1958, *St. John.* Jieroru: 21 May 1946, *Taylor 46-1,246.* Eniwetok: observed 1944, *Bryan;* 13 May 1946, *Fosberg 24,293;* observed 1949, *St. John.* Igurin: 14 May 1946, *Fosberg 24,315;* observed 1946, *Taylor,* and 1949, *St. John.* Mui: 9 August 1958, *St. John 26,319.* Rigili: 10 August 1949, *St. John 23,748.*

SOLANACEAE

79. *Nicotiana glauca* Graham. Shrub 2–4 m. tall, glabrous; branches erect, wandlike; petioles 2–8 cm. long; blades 3–16 cm. long, ovate, acute, often cordate, pale, glaucous; flowers in terminal panicles with subulate bracts; calyx 10–12 mm. long, ovoid, faintly angled, 5-toothed; corolla 27–37 mm. long, yellow, tubular, puberulent, the lobes 1–2 mm. long, low deltoid; capsules 9–10 mm. long, ovoid; seeds 0.5 mm. long, brown. Introduced weed.

Engebi: 4 April 1954, *Palumbo 1,124.*

80. *Physalis angulata* L. var. *angulata.* Short-lived herb, 15–90 cm. tall; puberulous especially on younger parts (or glabrous); petioles 1–4 cm. long; blades 4–10 cm. long, ovate to ovate-lanceolate, subentire or more or less salient toothed; pedicels in flower 5–15 mm. long, in fruit 20–30 mm. long; calyx in flower 4–5 mm. long, in fruit 25–35 mm. long, inflated, greenish; corolla 4–10 mm. long, yellowish; anthers 1–2.3 mm. long; seeds 1.6–1.8 mm. long, reniform, flat, reticulate, yellowish. Weed introduced from North America.

Japtan: 12 September 1957, *Lane 57-139.* Parry: 16 August 1957, *Lane 57-101.*

81. *Solanum Lycopersicum* L. Short-lived herb, viscid hirsute 0.3–1.6 m. tall; leaves 15–45 cm. long; petioles 20–45 mm. long; odd-pinnate, the large leaflets 5–10 cm. long, ovate or ovate-lanceolate, mostly alternating with tiny secondary leaflets; racemes 3–7-flowered; calyx 10–15 mm. long, the lobes lance-linear; corolla 7–12 mm. long, blue, the lobes lanceolate; berry 0.7–10 cm. long, subglobose, red or yellow, edible. The tomato, cultivated for its edible fruit.

Engebi: May 1944, *Fosberg.* Eniwetok: observed 1944, *Bryan.*

RUBIACEAE

82. *Guettarda speciosa* L. "Wut." Tree up to 8 m. × 15 cm.; young twigs puberulent; leaves opposite; stipules 10–14 mm. long; petioles 1–3.5 cm. long, glabrate; blades 10–23 cm. long, broadly obovate to suborbicular, below sparsely hirtellous, the base rounded or cordate; cymes 6–17 cm. long, axillary; calyx campanulate; corolla appressed puberulent, white, fragrant, the tube 35–40 mm. long, the 4–9 lobes oval; drupes 2.5–3 cm. diameter, white.

Bogombogo: 31 May 1946, *Taylor 46-3,110.* Elugelab: observed 1946, *Taylor.* Bogon: 11 August 1949, *St. John 23,773.* Engebi: 21 August 1944, *Bryan;* 18 May 1946, *Fosberg 24,398;* observed 1949, *St. John.* Aitsu: 13 August 1949, *St. John 23,793.* Rujoru: 2 June 1946, *Taylor 46-1,328;* observed 1949, *St. John.* Aomon: 16 May 1946, *Fosberg 24,364;* 4 June 1946, *Taylor 46-1,349.* Biijiri: 14 August 1949, *St. John 23,815.* Runit: 24 May 1946, *Taylor 46-1,254;* 15 August 1949, *St. John 23,843.* Aniyaanii: 25 May 1946, *Taylor 46-1,278.* Japtan: 15 May 1946, *Fosberg 24,318;* observed 1946, *Taylor,* and 1949, *St. John.* Parry: observed 1944, *Bryan;* 6 August 1958, *St. John 26,304.* Jieroru: 2 May 1946, *Taylor 46-1,244.* Eniwetok: 13 May 1946, *Fosberg 24,294;* observed 1949, *St. John.* Igurin: 14 May 1946, *Fosberg 24,312;* observed 1949, *St. John.* Rigili: 10 August 1949, *St. John 23,745;* 1 August 1956, *Rainey.*

83. *Morinda citrifolia* L. "Nen." Shrub or slender tree up to 8 m. tall, glabrous; leaves opposite; stipules 2–3 cm. long, rounded; petioles 1–4 cm. long; blades 10–35 cm. long, elliptic or ovate; flowers in axillary heads about 2.5 cm. long; calyx entire; corollas white, the tube 10 mm. long, the 4 lobes 5 mm. long, elliptic; syncarp 5–10 cm. long, ellipsoid, honey-colored, bitter, medicinal.

Engebi: observed 1944, *Bryan;* 18 May 1946, *Fosberg 24,381;* 12 August 1949, *St. John 23,780.* Aomon: 16 May 1946, *Fosberg 24,350.* Biijiri: 14 August 1949, *St. John 23,822.* Aniyaanii: 8 August 1949, *St. John 23,723;* 25 August 1957, *Lane 57-117.* Japtan: 15 May 1946, *Fosberg 24,335;* observed 1946, *Taylor,* and 1949, *St. John.* Eniwetok: 6 August 1949, *St. John 23,705.* Igurin: 14 May 1946, *Fosberg 24,302;* observed 1949, *St. John.*

CUCURBITACEAE

84. *Citrullus vulgaris* Schrad. Short-lived, trailing vine, hirsute; stems 1–6 m. long; petioles 2.5–10 cm. long; blades 7–20 cm. long, bi-tripinnatifid; peduncles axillary, shorter than the leaves; calyx 8–10 mm. long; corolla 18–22 mm. long, rotate, deeply 5-parted, the lobes obovate; fruit 20–60 cm. long, globose to ellipsoid; pulp red, edible; seeds 15 mm. long, obovate, black. The introduced watermelon.

Engebi: old garden, May 1946, *Fosberg.* Eniwetok: American gardens, observed 1944, *Bryan.*

85. *Cucumis Melo* L. Trailing, hirsute vine; stems 1–3 m. long; petioles 3–6 cm. long; blades 4–13 cm. long, orbicular-ovate to reniform, mostly 5-angled, sinuate dentate; calyx lobes 3–4 mm. long, linear; corolla 15–17 mm. long; fruit 10–30 cm. long, globose to ellipsoid, pulp edible; seeds 4–6 mm. long, pale. The introduced cantaloupe.

Engebi: in old gardens, May 1946, *Fosberg.*

86. *Cucurbita maxima* Duch. Short-lived, trailing vine, hispid; stems 2–10 m. long; petioles 20–40 cm. long, blades 25–40 cm. long, suborbicular, shallowly serrate, deeply cordate; flowers single; pedicels 10–30 cm. long, not swollen at apex in fruit; calyx lobes 3–10 mm. long, linear; corolla 6–8 cm. long; fruit 10–50 cm. long, variable in shape and color. The cultivated squash.

Engebi: May 1946, *Fosberg 24,376* and *24,380*. Eniwetok: American gardens, observed 1944, *Bryan*.

87. ? *Lagenaria siceraria* (Molina) Standl. Bottle Gourd. ? Engebi: there is a report by MacMillan and Smith, 1946, of observing a cultivated plant "probably *Lagenaria*." This is deemed doubtful and not to be accepted unless confirmed by other records.

GOODENIACEAE

88. *Scaevola frutescens* (Mill.) Krause var. *frutescens*. "Mar kinat." Shrub, 1–6 m. tall, branching and forming thickets; leaves alternate, without stipules, in terminal plumes, the cuneate leaf base merging into an indefinite petiole; blades 7–25 cm. long, cuneate-obovate or oblance-elliptic, thick, usually concave below, glabrous or almost so; cymes 2.5–8 cm. long, 5–9-flowered; calyx lobes 1.5–3 mm. long, lanceolate; corolla 12–16 mm. long, white except for the magenta nerves in the lobes; berries 10–12 mm. in diameter, globose, pithy, white. The most abundant shrub, especially near the shore.

Bogombogo: 31 May 1946, *Taylor 46-1,308*. Elugelab: 2 June 1946, *Taylor 46-1,322*. Bogon: 11 August 1949, *St. John 23,764*. Engebi: observed 1944, *Bryan;* 11 May 1946, *Fosberg 24,397;* observed 1949, *St. John*. Aitsu: 13 August 1949, *St. John 23,790*. Rujoru: 2 June 1946, *Taylor 46-1,327;* observed 1949, *St. John*. Aomon: 16 May 1946, *Fosberg 24,361:* observed 1949, *St. John*. Runit: 24 May 1946, *Taylor 46-1,266A*. Aniyaanii: 25 May 1946, *Taylor 46-1,271;* 8 August 1949, *St. John 23,722*. Japtan: 15 May 1946, *Fosberg 24,336;* observed 1946, *Taylor*, and 1949, *St. John*. Chinimi: observed 1946, *Taylor*. Parry: observed 1944, *Bryan*. Jieroru: 21 May 1946 *Taylor 46-1,247*. Eniwetok: 13 May 1946, *Fosberg 24,291;* observed 1949, *St. John*. Igurin: 13 May 1946, *Fosberg 24,314;* observed 1946, *Taylor*, and 1949, *St. John*. Mui: 9 August 1958, *St. John 26,320*. Rigili: 10 August 1949, *St. John 23,751*.

89. *Scaevola frutescens* (Mill.) Krause var. *sericea* (Forst. f.) Merr. "Mar Kinat." Like the species, but the foliage, white sericeous from the abundant, appressed pilosity.

Biijiri: 14 August 1949, *St. John 23,823*. Runit: 15 August 1949, *St. John 23,847*. Rigili: 1 August 1956, *Rainey*.

COMPOSITAE

90. *Erigeron bonariensis* L. *E. albidus* (Willd.) Gray. Short-lived herb, 1–2.7 m. tall, slender and unbranched to the inflorescence; canescent throughout; leaves alternate, sessile or with petioles to 3 cm. long; blades 2–10 cm. long, linear-lanceolate; panicle terminal, 20–60 cm. long, leafy; involucral bracts 4 mm. long, in 2–3 series; flowers white; achenes 1.5 mm. long, the pappus stiff. Introduced weed.

Eniwetok: 6 August 1949, *St. John 23,708*.

91. *Lactuca sativa* L. Short-lived, smooth herb, first forming a rosette with leaves 12–25 cm. long, obovate to orbicular, sessile; soft, edible; later producing a single, leafy stalk 1–1.3 m. tall; cauline leaves much smaller, auriculate and serrate; panicle terminal; heads with 12–16 yellow ray flowers; achene lenticular; pappus silky. The cultivated lettuce.

Eniwetok: in American gardens, observed 1944, *Bryan*.

92. *Pluchea indica* (L.) Less. Shrub, 0.6–2 m. tall; leaves alternate, 15–55 mm. long, oblanceolate, denticulate; cymes 2–7 cm. long, several headed; involucre 3–4 mm. high; bracts firm, in several series; flowers pink, pappus silky. Introduced weed.

Eniwetok: 6 August 1949, *St. John 23,704*.

93. *Pluchea odorata* (L.) Cass. Vigorous herb 1–3 m. tall, soft pilose; leaves alternate; petioles 0.5–2 cm. long; blades 8–15 cm. long, densely white pilose beneath; corymbs numerous, many headed; involucre 5 mm. high; flowers creamy. Introduced weed.

Eniwetok: 6 August 1949, *St. John 23,703*.

94. *Vernonia cinerea* (L.) Less. "Senailing nagailing." Short-lived herb, 20-60 cm. tall, freely branching, cinereous puberulent; petioles

0–10 mm. long; blades 2.5–3.2 cm. long, the lower ones lanceolate to obovate; the upper smaller and linear; panicle terminal; involucre 2.5 mm. long, the bracts unequal, in several series; corollas as long as the involucre, bluish; achenes 1 mm. long, the pappus white, stiff. Introduced weed.

Engebi: 4 April 1954, *Palumbo 1,123*. Eniwetok: 6 August 1949, *St. John 23,710*.

95. *Wedelia biflora* (L.) DC. "Marguegue." Arching and half-sprawling shrub; stems 2–10 m. long; leaves opposite; petioles 1–3 cm. long; blades 5–10 cm. long, lance-ovate, distantly serrate, sparsely appressed hirsutulous; peduncles terminal, mostly in 3's with 1–2 heads; involucre 4 mm. long, the bracts unequal, in several series; ray florets bright yellow, about 8, the rays 5 mm. long; disk florets numerous, each wrapped in a palea; their achenes 3 mm. long, commonly without pappus.

Engebi: observed as "yellow composite vine," 1944, *Bryan*; 18 May 1946, *Fosberg 24,391*.

96. *Zinnia elegans* Jacq. (?) Short-lived herb, 1.5–1 m. tall; leaves opposite, 2.5–5 cm. long, ovate to elliptic, hispidulous; heads solitary, 5–13 cm. across; involucral bracts round or elliptic, dark-tipped; ray flowers elliptic, of numerous rich colors; disk orange; achenes 5–6 mm. long, flattened, obovate, winged.

Eniwetok: in American gardens, observed as *"Zinnia,"* 1944, *Bryan*.

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Marine Copepods of the Genus *Anthessius* from the Northeastern Pacific Ocean[1]

PAUL L. ILLG[2]

AMONG THE COPEPODS associated with invertebrates there is a remarkably homogeneous collection of species, predominantly associated with mollusks, comprising the genus *Anthessius* Della Valle 1880. The indications are strong that the mollusks will exclusively furnish the hosts of the members of the genus. Investigations of the invertebrate fauna of the Pacific Coast of the United States has resulted in the discovery of four species. One of these, *Anthessius navanacis* (Wilson, 1935), is known from California due to the fruitful ecological studies of Professor and Mrs. G. E. MacGinitie. From collections of the U. S. Steamer "Albatross," we have from Hawaii *Anthessius hawaiiensis* (Wilson, 1921). In the description of new species in a genus so anatomically consistent, it was necessary to invoke details not available in the original descriptions of these older species. Accordingly, they are redescribed below, with some emendations.

For support of much of the research contributing to this paper I am indebted to Fund 171, State of Washington. The illustrations for three species are based on pencil renderings by Mr. R. U. Gooding. Other drawings and the writing of the paper have been completed during the tenure of a John Simon Guggenheim Memorial Foundation Fellowship. I am indebted to many colleagues for assistance in connection with this report, and am most particularly obliged to Mr. John E. Fitch for his considerable efforts in collecting for me the material of the species named for him below.

The genus *Anthessius* Della Valle dates from 1880, with two species described as associates of Mediterranean mollusks. A still earlier species is now included in the genus. This is *Boeckia arenicola* Brady 1872*a*, 1872*b*. As *Boeckia* is a preoccupied generic name, Brady subsequently referred to this species as *Lichomolgus arenicolus* (1880: 46–47). It has been referred to in this combination by several authors, and also as *Herrmannella arenicola*, following T. Scott (1898). No host was known for this species until Bocquet and Stock (1958) demonstrated that *A. arenicolus* is an associate of *Dosinia exoleta* (L), and, further, clarified the systematic confusion of this species with their *A. teissieri* 1958 in much of the published record. Such reinvestigations as that of Bocquet and Stock of many of the known species are needed to solve bionomic problems and to expand anatomical descriptions for provision of a sound basis for the resolution of the discrepancies found in the literature on the systematics of the genus. The work of these authors added to the revisionary summary of Monod and Dollfus (1932) and the review of Sewell (1949) provide the basis for the present treatment of the group. In the published record so far, the genus is still referred to the family Lichomolgidae, although the appropriateness of this attribution has already been questioned (Illg, 1949: 393). Myicolidae Yamaguti 1936 is available in Cyclopoida Poecilostoma among the families in the complex containing Clausidiidae and Lichomolgidae. I follow de Vos in Korringa and Lambert (1951: 18–19) in assigning *Lichomolgus spinosus* Raffaele e Monticelli 1885 not to *Anthessius*, but to the closely related genus, *Pseudomyicola* Yamaguti 1936. *Pseudomolgus* Sars 1916 is a synonym of *Anthessius* and the list of species so assigned must be transferred, as shown by Monod and Dollfus. The group of species now comprising *Anthessius* form a most coherent series of forms for which some morphological generalizations now can be made. Considerable emphasis has been laid by some authors on the importance of the condition of the segment of the first legs, relative to its alternative fusion with or separation from the cephalosome. Study of five species leads me to conclude that typically

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the cephalosome in the genus functionally includes the segment of the first legs. However, the legs themselves seem to function as part of the metasomal series of legs. The anterior part of the segment on the ventral side is involved in the formation of a posterior termination of the oral region. Functionally, then, the transition from cephalosome to metasome is strongly indicated as intrasegmental. In none of the species I have studied does the separation of the segment of the first legs from the anterior region seem to involve as free an articulation as that between successive pedigerous segments, although a well-developed inflected interruption of the integument may provide a conspicuous anterior boundary for the element. In the paratypic material of *A. navanacis* this feature was found to vary, one female being found with a well-developed suture indicating the segmental boundary, a second female showing no interruption of the integument.

The structure and ornamentation of the antennule emerge as remarkably consistent throughout the species and it is strongly probable that a basic form as well as a characteristic ornamentation will be found consistently when details have been presented for all species. A very interesting dichotomy exists with regard to sexual dimorphism in the armature of this appendage. Bocquet and Stock were the first to point out the remarkable complement of aesthetes in the antennule of males of *A. arenicolus* and *A. teissieri*. As can be seen by comparing their findings and the descriptions below, there is apparently a typical distribution of aesthetes on the antennules of females, these occurring regularly on segments 5, 6, and 7. Bocquet and Stock described in the males of the species they studied this same complement of aesthetes with additional aesthetes found on segments 2 and 4. Exactly the same pattern was found in the new species described below, *A. lighti*. However, on the basis of careful study of equally favorable material of *A. nortoni* and *A. fitchi*, both new species, I can say that no such dimorphism exists in these species. It will be of interest to see how this feature is found to be distributed among the species of the genus. Unfortunately the type material of *A. navanacis* available to me was not sufficiently well preserved to make possible determination of this feature, and for *A. hawaiiensis* I could not find males.

The antennae and the mandibles, maxillules, and maxillae are extremely similar throughout the species of the genus, so that a generic pattern might very soundly be said to exist, although there are minute details of specific variation. The maxillipeds, highly dimorphic in the sexes, are also somewhat more strongly specifically distinctive in details of ornamentation than are the other mouthparts. The swimming legs have a very consistent pattern of structure and ornamentation throughout the genus, with, however, fairly distinctive specific features of outline and proportion of segments and of fine details of minute ornamentation. Two major alternative patterns of armature appear through the series of species, some having three spines on the terminal segment of the fourth exopodite, some having four spines there. In all the species below in which I have been able to study both sexes (four of the five), I have found a sexual dimorphism of the first legs. On the terminal segment of the endopodite there is a spine and five setae in the female, two spines and four setae in the male. The species involved are sufficiently diverse in their other variable characteristics that I would venture to predict on the basis of these that such dimorphism will probably be found consistently throughout the genus.

The basic pattern of the fifth legs is consistent among the species, but there are distinctive variations in proportions and in the placement of the elements of the armature. There is a sexual dimorphism characteristically in this appendage, also, but the variation may be very subtle in degree in some species. Dimorphism of the caudal rami also seems substantially indicated, but for this feature additional investigation of the previously known species is required. Finally, with regard to sexual dimorphism it should be stated that in this group, where unusually large cyclopoid species are included, there is remarkably little difference in size of males and females in many of the species. More information is needed on this feature, but the situation is particularly striking in such a distinctive species as *A. fitchi*, described below, which is gigantic and equipped with strongly developed epimerae. The male is slightly larger than the female, which is

unusual among poecilostome groups in general.

Reaching systematic conclusions in the genus *Anthessius* is difficult. The descriptions of many of the species are fragmentary or deal with details which are not readily comparable with those furnished in still other descriptions, so that the relatively subtly differentiated species become difficult to characterize as distinctive, although the information available convinces the taxonomic worker of the specific separation of the forms. Some characteristics which seem to serve for grouping species are discussed below. Finally a very rough key is presented to serve the function of demonstrating the specific separation of the new species described. As most of the features treated in the key are drawn from the literature, some of which is unsatisfactory for the details involved, it is to be regarded only as a synopsis, not as a reliable device for routine identification of species.

In general, the fifth leg of species is usually described and depicted with considerable detail and care. Grouping on the basis of this appendage should be fairly reliable. In *A. solecurti* Della Valle, the structure as figured and described is unique for the genus and readily serves to differentiate the species. Among the remaining species there are two general types of contour seen in the fifth leg of females. (The male of *A. investigatoris* Sewell 1949 has to be involved in this discussion, as the female of the species is not known.) In most species, the lateral margins of the free segment of the fifth leg are essentially parallel, although there may be some constriction at the base or toward the apex. In all, the appendage is narrow, so that the ratio of length to greatest width is much more than 3, ranging from about 3.2 to 4.5 or more. In the fifth leg of the remaining species the free segment is much broader and more platelike. The margins tend to expand and the armature may be concentrated on or near a broad distal margin. In such forms the ratio of length to width of the free segment is much less than 3, ranging from about 1.8 to 2.7, as discernible from figures accompanying descriptions in most cases. *A. navanacis* (Wilson), which is assignable to this group, is also readily separated from all members of the genus by the distinctive outline of the fifth leg, with marked basal constriction. Few anatomical details are available for *A. pleurobrancheae* Della Valle, but in the description the structure of the fifth leg is stressed, and this species is unique among those falling into the category just described by completely lacking marginal ornamentation of spinules on the free segment. As remarked above a useful dichotomy exists with regards to the armature of the fourth swimming legs, but this detail is not available from all species descriptions. Finally, there are readily determinable groupings available based on the ratio of length to width of caudal rami, and in most descriptions information on this feature or fairly good illustration is provided. The degree of variability of this character in any given species remains to be determined.

KEY TO SPECIES OF *Anthessius*

Based on adult females, but including *A. investigatoris* Sewell 1949 on the basis of the male. *A. pleurobrancheae* Della Valle 1880 has been included, after the treatment of Stock (1959), although the original description was very scanty and Claus' account (1889) does not extensively supplement Della Valle's. Species recently described (Humes, 1959; Stock, 1959) have been included in the key, but were not treated in the discussions in this paper.

1a. Body habitus very modified, cephalosome much expanded in outline, thoracic segments with widely extending epimera, caudal rami elongate, laminate ..... ***fitchi,*** new species

1b. Body in general approaching typical cyclopoid habitus 2

2a. Ratio of length to width of terminal segment of fifth leg more than 3 3

2b. Ratio of length to width of terminal segment of fifth leg less than 3 12

3a. Terminal segment of exopodite of fourth leg with 4 spines 4

3b. Terminal segment of exopodite of fourth leg with 3 spines 9

4a. Ratio of length to width of caudal ramus about 1 ..... *brevifurca* Sewell 1949

4b. Ratio of length to width of caudal ramus much more than 1 5

5a. Maxilla bearing more than 10 external marginal teeth.....*pleurobrancheae* Della Valle 1880
5b. Maxilla bearing at most 6 external marginal teeth 6
6a. Ratio of length to width of caudal ramus about 2.6.....***lighti,*** new species
6b. Ratio of length to width of caudal ramus about 4..... 7
7a. Interior margin of fifth leg bearing distal group of slender spinules at distal third and a group of slender spinules in the middle of the segment.....*arenicolus* (Brady 1878)
7b. Interior margin of fifth leg bearing, with exception of distal group of slender spinules at distal third, no spinules or setae 8
8a. Ventral surface of last segment of urosome with 2 prominent rows of strong spinules.....*solecurti* Della Valle 1880
8b. Ventral surface of last segment of urosome with 2 rows of hardly discernible spinules.....*teissieri* Bocquet and Stock 1958
9a. Ratio of length to width of caudal ramus about 1.5.....*investigatoris* Sewell 1949
9b. Ratio of length to width of caudal ramus much more than 1.5.....10
10a. Ratio of length to width of caudal ramus about 3.....***nortoni,*** new species
10b. Ratio of length to width of caudal ramus more than 3.5.....11
11a. Terminal segment of antenna at least twice as long as wide.....*leptostylis* (Sars 1916)
11b. Terminal segment of antenna about 1.5 times as long as wide.....*dilatatus* (Sars 1918)
12a. Terminal segment of fourth exopodite with 4 spines.....13
12b. Terminal segment of fourth exopodite with 3 spines.....16
13a. Maxilla with low apical sclerotized portion, not inclining anteriorly in marked angle to remainder of appendage.....*hawaiiensis* (Wilson 1923)
13b. Maxilla with apical portion erect, large, sharply angled 14
14a. Exterior margin of fifth leg without spinules or setae.....*groenlandicus* (Hansen 1921)
14b. Exterior margin of fifth leg with row of spinules or setae.....15
15a. Exterior margin of fifth leg bearing only about 5 short, stout, conical spinules .....*minor* Stock 1959
15b. Exterior margin of fifth leg bearing many long, slender spinules or setules .....*concinnus* (A. Scott 1909)
16a. Second and fourth segments of antennule extremely elongate, over 4 times as long as wide .....*navanacis* (Wilson 1935)
16b. Second and fourth segments of antennule of moderate proportions, less than 3 times as long as wide.....*pinnae* Humes 1959

The literature contains references to species of *Anthessius* which have not yet received formal systematic characterization: *Pseudomolgus* sp. Wilson (1921: 15); *Pseudomolgus* sp. Wilson (1923: 4); and *Anthessius* sp. Humes and Cressey (1958: 935).

Anthessius Della Valle 1880

Boeckia Brady 1872*a*; Brady 1872*b*.
Lichomolgus Brady 1880 (pars); auctorum.
Anthessius Della Valle 1880; Canu 1891; Monod and Dollfus 1932; auctorum.
Hermanella Thompson and Scott 1903 (pars); auctorum.
Pseudomolgus Sars 1916; auctorum.

The complete synonymy of the genus is not given here, although the basis for tracing all references is provided in the above and the bibliographies provided in the references cited. There are several systematic problems connected with the genus still to be clarified.

In many regards the diagnosis of the genus provided by Della Valle still holds, although some of his characters were erroneous. However the modern definition may well be based on the original description. The body is mostly cyclopoid, but some considerable elaboration of body processes may occur. The segment of the first legs is functionally involved with the cephalosome in part and may be entirely anatomically

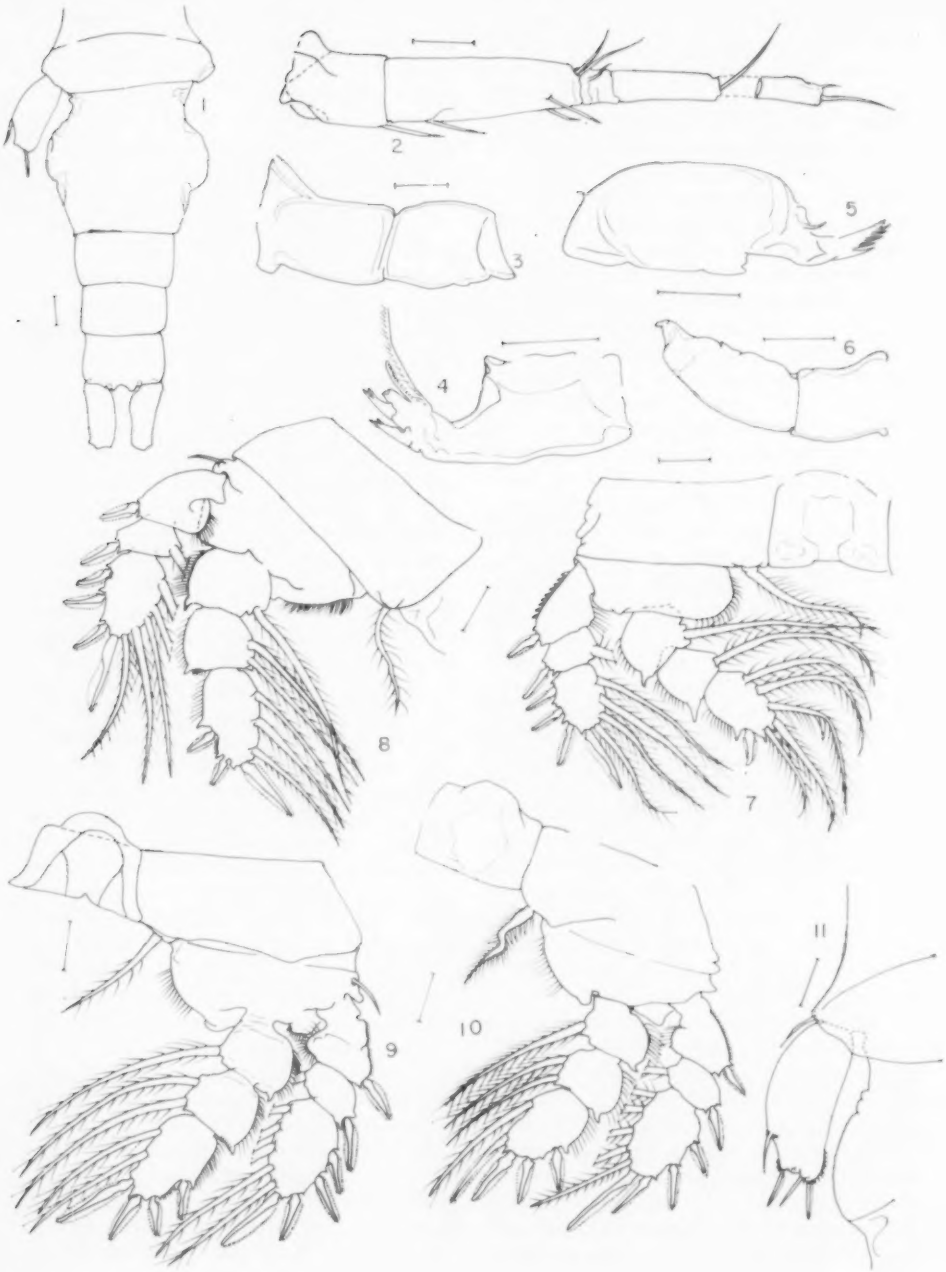
fused. The antennule is 7-segmented. The antenna is 3-segmented, the basal 2 segments each with 1 seta, the terminal segment with several setae and several characteristic articulated hooks. The mandible is an unsegmented flat plate tapering apically in a long setiform process. An equally well-developed accessory process is articulated on the anterior margin just proximal to the distal lash. Marginal ornamentation is strongly developed in both elements. The maxillule is a flat plate, with expanded and somewhat incised apical margin, with armature consisting of an articulated spine and seta. The maxilla has a greatly expanded basal segment, the flat apical segment tapering and bending anteriorly to form a heavily cuticularized element with right-angled outline, usually with 1 accessory articulated spine or seta, and with the margin developed as a series of conspicuous spinous processes. The maxilliped of the female is obscurely 3-segmented, with reduced armature. In the male the maxilliped is 3-segmented, the terminal 2 segments participating in a characteristic subchela. Hand of subchela inflated and with ornamentation of spinules and spines. Finger of subchela very elongate and bearing accessory seta. Legs 1 to 4 biramous, all rami trimerous. Armature well developed, the most characteristic pattern being that of the terminal segments of the third endopodite, bearing 4 spines and 2 setae; that of the terminal 2 segments of the fourth endopodite, bearing on segment two 2 setae, on three 1 seta and 4 spines; and that of the terminal segment of the fourth exopodite, this bearing 5 setae and alternatively 3 or 4 spines. The fifth leg has 1 free segment, the basal element being only a setiferous prominence of the body segment. The flat, elongate free segment bears four elements of armature, characteristically 3 spines and a seta. The sixth legs are not particularly distinctive among those of poecilostomes, and the caudal rami are variable in proportions, although the typical cyclopoid armature is consistently well developed.

Sars designated *Boeckia arenicola* Brady as the type of *Pseudomolgus*. The type for *Anthessius* has not yet been fixed, but must be selected from one of the two original species of Della Valle, *A. pleurobrancheae* and *A. solecurti*. On the basis of the redescription and extensive illustration of *A. solecurti* by Stock (1959), this species is herewith designated as the type of the genus.

Anthessius hawaiiensis (Wilson)
Figs. 1–11

Pseudomolgus hawaiiensis C. B. Wilson 1921. Type locality off South Coast of Molokai, Hawaiian Islands, "Albatross" Station 3853, type host *Pleurobranchus* sp.

SPECIMENS EXAMINED: Wilson's types were seen in the U. S. National Museum and were found to compare reasonably well with the habit figures he presented, although none were in good condition. A female paratype, USNM 53565, was dissected, and although some of the appendages were lost in preservation and some in dissection of the fragile specimen, a description was prepared to provide details for comparison with the species described below. Wilson used a different terminology for mouthparts from that now current, so his statements about the first maxilla refer to our mandible, his palp of first maxilla is our maxillule, but his second maxilla corresponds to our usage. His description in general corresponds to the type specimens, but his illustrations are variable in reliability. The antennule and antenna are very generally depicted, without providing details of armature. The mandible is generally illustrated, although some details of the armature are lacking. The maxillule is inadequately depicted. The maxilla is presented in essential outline, but the detailing is somewhat misleading. He indicates more processes on the terminal segment than the type material corroborates. For the female, the first leg is essentially depicted, although the figure does not indicate completely the apical spine of the terminal segment of the exopodite. The second and third legs are illustrated in essential rough outline. The illustration of the fourth leg presents serious discrepancy from that for the male and from the type material. The exopodite is not depicted as possessing on the terminal segment the 3 lateral and 1 terminal spines illustrated for the male and which I find on the paratypic female. The figure of the endopodite corresponds in rough essentials. The illustration of the fifth leg cor-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responds in rough essentials to the paratype, but the armature was incompletely represented. For the male, the third leg was represented as corresponding in rough essentials to the female, the fourth leg was illustrated so that the exopodite corresponds to what I found in the female paratype and serves to indicate a correction can be made in the illustration for the female. However the illustration of the endopodite does not represent the condition found in any *Anthessius* male I know of. This figure then is subject to question. The figures 55, 56, representing the fifth leg of the male, do not agree. I was unable to reinvestigate the appendage.

DESCRIPTION: Female (Figs. 1–11), body length 4 mm., greatest width 2 mm., based on Wilson's original description. Body of rather generalized cyclopoid contours, but with most thoracic and abdominal segments distinct, so that regionalization is not emphatic. Cephalosome a fused complex bearing appendages through first swimming legs and comprising .34 of total body length, measured from apex of cephalosome to end of a caudal ramus. Segment of first legs not free, but strongly indicated by lateral indentations and surface grooves. Metasome including segments of second through fourth legs, with general body articulation between segments of legs 4 and 5. Urosome (Fig. 1) a complex including segment of legs 5, genital segment and 3 additional abdominal segments, considering element bearing anal opening and supporting caudal rami as terminal segment. Urosome comprising .41 of total body length. Genital segment expanded laterally.

Antennule (Fig. 2) essentially 7-segmented, but with complicated articulation and integumental modification between second and third segments, so as to suggest either coalescence or incipient separation of an additional minute segment. Approximate proportional lengths of segments, basal to distal: Segment I, 3; II, 6; III, 1; IV, 3.5; V, 2; VI, 1; VII, 1. Setae varying in length; count per segment indeterminable in available material.

Antenna (Fig. 3) with segmental composition much obscured by additional flexures, involving integumental folds, and torsions of one region of appendage on adjoining regions, but probably essentially 3-segmented. Basal segment clear-cut, apical articulation transverse, no armature determinable. Second segment with very complicated distal articulation, this proceeding diagonally across appendage; no armature determinable. Terminal segment with cuticularized ridges and folds and with very broad distal margin furnishing insertion for elaborately articulated clawlike elements and setae. Details of armature indeterminable from available material.

Mandible (Fig. 4) a flat plate, with very cuticularized anterior and posterior margins. Appendage terminating in long lashlike blade with complicated marginal ornamentation. Two most basal elements of ornamentation flat toothlike structures, compound apically and articulating with margin of appendage. Remainder of ornamentation a long row of graduated denticles. On anterior margin articulated a long lashlike auxiliary seta with conspicuous graduated row of cilia on outer margin. Between apical lash and auxiliary seta an articulated cuticular piece with some marginal ornamentation.

Maxilla (Fig. 5) with very long articulation with body surface, resulting in characteristic massive basal segment, on which articulates flattened apical segment with heavy cuticularization. Apex produced in sharp angle anteriorly with toothlike expansions of cuticle forming a medial saw-edge. Five marginal teeth, formed by flangelike protrusions of cuticle. Apex produced as short spinelike process. Inserted at base of angle of curvature of this segment and lying on its surface an articulated setule.

Maxilliped (Fig. 6) fairly long, 2-segmented. Basal segment a little over half as long as distal. Terminal segment with apical spinelike process. Margins somewhat cuticularized.

First legs (Fig. 7) with well-developed bimerous protopodites, yoked by substantial inter-

FIGS. 1–11: *Anthessius hawaiiensis* (Wilson). The scales accompanying certain figures represent 0.1 mm. Female: 1, urosome; 2, antennule; 3, base of antenna; 4, mandible (partial); 5, maxilla; 6, maxilliped; 7, first leg; 8, second leg; 9, third leg; 10, fourth leg; 11, fifth leg.

coxal plate. Basal width of basipodite less than width of distal margin of coxopodite, so medial seta of coxopodite inserted on free portion of margin. Coxopodite seta very long, extending rather more medially than distally, its length slightly greater than width of intercoxal plate. Basipodite with row of cilia on curving medial margin. Armature of trimerous exopodite: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 3 medial setae. First segment with fine spinules on lateral margin and row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate hyaline flange. Apical spine with external hyaline flange and entire inner margin. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 1 medial seta; third segment, 1 lateral spine, set in distinct emargination, 2 apical setae, 3 medial setae. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spine of terminal segment subtended by such process, and with outlining hyaline flange. Every segment with row of cilia on lateral margin. Setae of coxopodite and rami with plumose ciliation.

Second legs (Fig. 8) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite on medial free portion of border of segment. Seta about as long as width of intercoxal plate. Basipodite with tiny lateral seta; medial margin with dense row of cilia. Exopodite trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and very small internal flange. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in steplike emarginations, 1 terminal spine, 3 medial setae. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spines of terminal segment subtended by such processes, but these somewhat less developed than those of basal segments. Spines of terminal segment with hyaline flanges. Each segment with row of cilia on lateral margin. Setae of coxopodite and rami with plumose ciliation.

Third legs (Fig. 9) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite, about equal to width of intercoxal plate, inserted on medial free portion of distal border of segment. Basipodite with small lateral seta; medial margin with row of cilia. Exopodite, extended almost directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, dense row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal margin entire. Trimerous endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in steplike emarginations, 2 terminal spines, 2 medial setae. Each of 2 basal segments produced at distal lateral corners as small spinous cuticular processes. Spines of terminal segment subtended by such processes, but these even less developed than those of basal segments. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. Setae of coxopodite and rami with plumose ciliation.

Fourth legs (Fig. 10) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite inserted on medial free portion of distal border of segment; length about equalling width of intercoxal plate. Medial margin of basipodite with short row of cilia. Exopodite, extended with slight flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with

external hyaline flange and internal margin entire. Trimerous endopodite with slight flexure. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines set in steplike emarginations, 2 apical spines, 1 medial seta. Medial setae of all segments reduced somewhat in length. Each of basal 2 segments produced slightly at distal lateral corner as small spinous cuticular process. Most proximal spine of terminal segment subtended by such process, and another apical on segment. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. Setae of coxopodite and rami with plumose ciliation.

Fifth legs (Fig. 11) with probably 2 segments represented, basal consisting only of expansion on body posteriorly and laterally to furnish articulation of distal segment, and with a small seta laterally, representing armature. Second segment broad, flattened with cuticularized medial and lateral margins. Length about 2.5 times greatest width. Armature 2 spines and 2 setae, spaced on lateral and terminal margins: 1 lateral seta at about distal .8 of lateral margin; 1 spine at lateral distal corner; 1 seta near medial distal corner; 1 apical spine at medial distal corner. Spines subtended by small groups of spinules, these continuing as short row on distal fifth of medial margin.

Caudal ramus about 2.5 times as long as greatest width and 1.15 times as long as anal segment. Setal armature not determinable from available material.

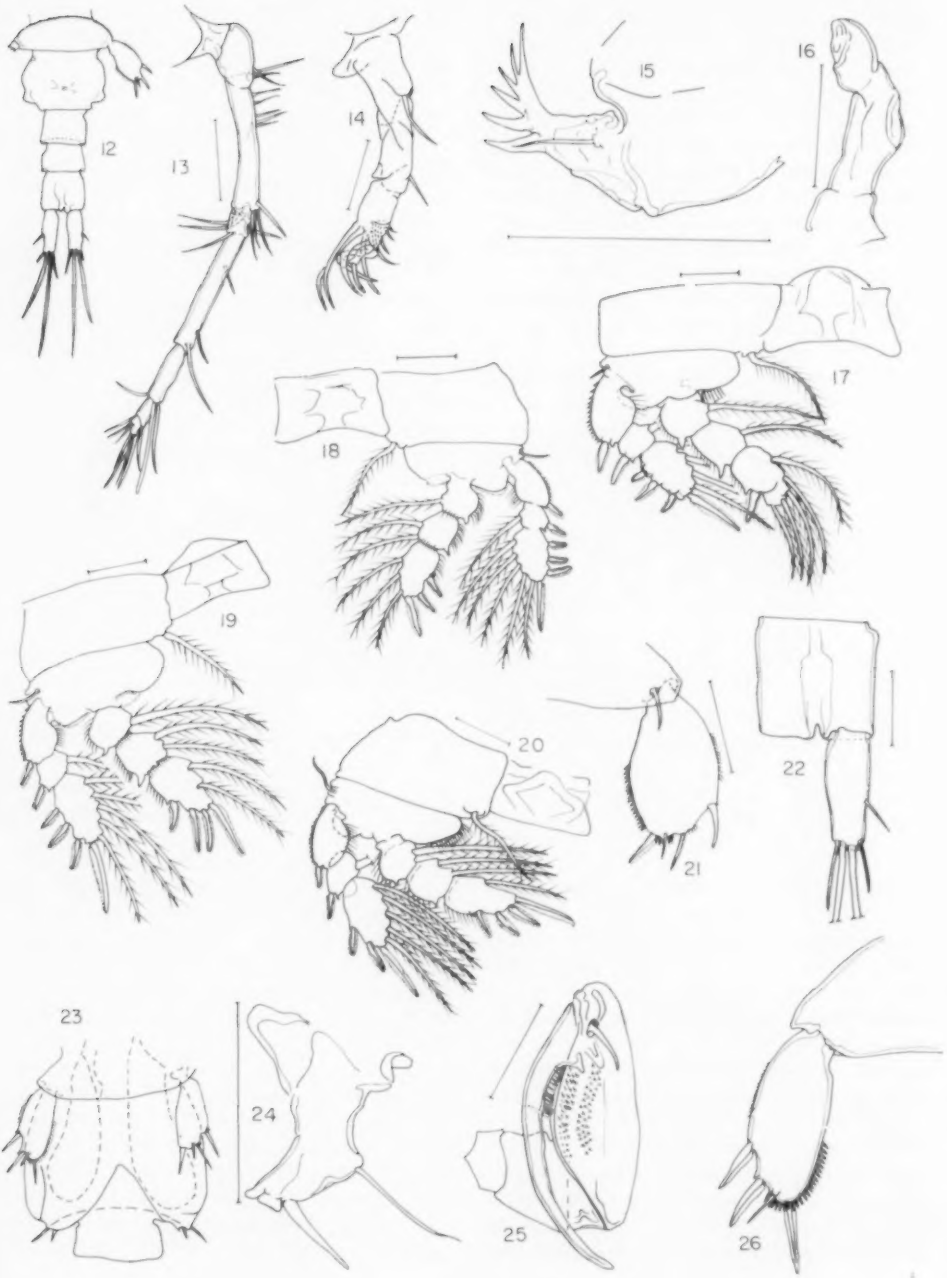
REMARKS: Due to the small amount of type material the male of this species could not be reinvestigated. According to the original description by Wilson the length of the male is 2.85 mm., the width 1.25 mm., and the usual features of anatomical dimorphism appear to occur. Attempts have been made to re-collect this species. The host, as indicated by the original description, quite possibly is a fairly common form in Hawaiian waters, but no further records of the copepod have come to light.

The species is differentiated from others of the genus in the key above. Many details of the anatomy should be reinvestigated when well-preserved specimens become available. The species is one of the larger ones known for the genus.

Anthessius navanacis (Wilson)
Figs. 12–26

Pseudomolgus navanacis, C. B. Wilson, 1935. Type locality, Laguna Beach, California, *Navanax inermis* (Cooper), type host.

SPECIMENS EXAMINED: Wilson's types were seen in the U. S. National Museum, and were found to compare reasonably well with the habit figures he presented (but see below, under body form). Two female paratypes and two male paratypes, one pair each from USNM 54082 and USNM 64062, were dissected to compare with the original description. The specimens showed some variation in body segmentation and in the strength of development of the spines of the swimming legs, but these were of minor grade. The specimens in some details in which they agree with each other do not correspond to some details of the original description and accompanying illustrations. Accordingly, the species is redescribed below, with details added for purposes of comparison with other species treated in the present study. Wilson was using a different terminology for mouthparts from that now current, so his statements about the first maxilla refer to our mandible. His description and figure for this appendage are in good agreement with generalities about *Anthessius* species, and, as I was unable to dissect out in good condition the mandible from the paratypes I examined, I can add no further information. Some important discrepancies in the descriptions and illustrations for other appendages in the original description should be noted. The armature described for the second antenna, 6 or 7 stout claws and 1 or 2 setae, does not correspond with the 4 claws and 7 setae described below. For the 4 pairs of swimming legs, a misinterpretation of the cuticular specializations of some segments led to presentation in the original description of an armature which does not correspond with any known for a species of *Anthessius*. The exopodites are adequately described and illustrated. For the endopodites, spinous processes were counted as spines and some other discrepancies from the condition in the para-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types occur. The illustration and description of the fifth leg in the female corresponds in rough essentials to the condition in the paratype, but one element of the armature was omitted. For the male, the maxilliped was described and figured in approximate correspondence with that of the paratypes, but Wilson overlooked a well-developed basal segment, so that the appendage was referred to as 2-segmented.

DESCRIPTION: Female (Figs. 12–22): Body length 2.0 mm., greatest width 1.40 mm., based on Wilson's original description. Body of rather generalized cyclopoid contours, but with metasomal and abdominal segments distinct, so that posterior regionalization is not emphatic. Cephalosome a fused complex bearing appendages through first swimming legs and comprising .4 of total body length, measured from apex of cephalosome to end of a caudal ramus. Original description stated that segment of the first legs is fused with the cephalothorax and indicated so as an antomical segment by slight marginal indentations. Paratypes (topotypic) from Laguna Beach (USNM 54082) showed the segment so clearly delimited as almost to justify considering it a free element. Paratypes from Anaheim Slough, California (USNM 64062) show fusion as in the original description.

Antennule (Fig. 13) essentially 7-segmented, but with complicated articulation and integumental modification between second and third segments, so as to suggest either coalescence or incipient separation of an additional minute segment, which if present would raise number to 8. Approximate proportional lengths of segments, basal to distal: Segment I, 3; II, 6.5; III, 1.5; IV, 6; V, 3; VI, 1.5; VII, 1. Setae varying in length, count per segment undeterminable due to poor preservation of available specimens.

Antenna (Fig. 14) with segmental composition much obscured by additional flexures, involving integumental folds, and torsions of one region of appendage on adjoining regions, probably essentially 3-segmented. Basal segment without clear-cut, apical articulation, bearing 1 short external seta. Second segment with very complicated distal articulation, this proceeding diagonally across appendage; 1 short seta distally and externally inserted. Terminal segment with cuticularized ridges and folds and with very broad distal margin furnishing insertion for 4 elaborately articulated clawlike elements and 2 setae. Another seta near distal margin. A subapical group of 4 setae of diverse lengths. Total elements—4 claws, 7 setae.

Mandible a flat plate, with cuticularized anterior and posterior margins. Appendage terminating in long lashlike blade with complicated marginal ornamentation. Two most basal elements of ornamentation flat structures compound apically and articulating with margin of appendage. Remainder of ornamentation a row of graduated denticles. On anterior margin of mandible articulated a long lashlike auxiliary seta with conspicuous marginal ornamentation.

Maxillule of characteristic type for genus, an elongate lobe with flaring apex. On apex a more medial spine and far lateral seta. More detailed description presented for male, below.

Maxilla (Fig. 15) with very long articulation with body. Characteristic massive basal segment, on which articulating flattened apical segment, with heavy cuticularization. Apex produced in sharp angle anteriorly, with toothlike expansions of cuticle forming medial saw-edge. Five large teeth formed by flangelike protrusions of cuticle. Apex produced as more elongate spinelike process, to total number of outgrowths 6. In some specimens there may be 1 more or 1 less tooth. Inserted at base of angle of curvature of distal segment, and lying on surface, an articulated, fairly long seta.

Maxilliped (Fig. 16) a prominent mouthpart, as seen in general habitus of mouth area, but with little development of segmentation or ornamentation. Three segments suggested by folds and flexures of integument. Terminal portion with folds and indentations of cuticularized surface, but with no elements of armature.

First legs (Fig. 17) with well-developed

FIGS. 12–26: *Anthessius navanacis* (Wilson). The scales accompanying certain figures represent 0.1 mm. Female: 12, urosome; 13, antennule; 14, antenna; 15, maxilla; 16, maxilliped; 17, first leg; 18, second leg; 19, third leg; 20, fourth leg; 21, fifth leg; 22, anal segment and caudal ramus. Male: 23, segments of fifth and sixth legs; 24, maxillule; 25, maxilliped; 26, fifth leg.

bimerous protopodites, yoked by substantial intercoxal plate. Basal width of basipodite less than width of distal margin of coxopodite, so medial seta of coxopodite inserted on free portion of margin. Coxopodite seta relatively long, extending rather more medially than distally, and with its length slightly less than the width of intercoxal plate. Basipodite with small lateral seta proximal to insertion of exopodite and with row of stout cilia on curving medial margin. Exopodite held at angle to protopodite, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 3 medial setae. First segment with fine spinules on lateral margin, row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 1 medial seta; third segment, 1 lateral spine, set in distinct emargination, 2 apical setae, 3 medial setae. Each of 2 basal segments produced at distal lateral corner as strong spinous cuticular process. Spine of terminal segment subtended by such process, and with outlining hyaline flange. Each segment with row of cilia on lateral margin. All setae of leg with plumose ciliation.

Second legs (Fig. 18) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite on medial free portion of border of segment. Seta about as long as width of intercoxal plate. Basipodite with small lateral seta; medial margin with cilia. Exopodite trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal margin entire. Endopodite slightly flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in steplike emarginations, 1 terminal spine, 3 medial setae. Each of basal 2 segments produced at distal lateral corner as small spinous cuticular process. Proximal spine of terminal segment also subtended by such process. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Third legs (Fig. 19) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite about as long as width of plate, inserted on medial free portion of distal border of segment. Basipodite with small lateral seta; medial margin with cilia. Exopodite, extended directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of spinules on lateral margin, row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal margin entire. Trimerous endopodite slightly flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines, set in steplike emarginations, 1 terminal spine, 2 medial setae. Each of 2 basal segments produced at distal lateral corner as moderately long spinous cuticular process. Proximal spine of terminal segment subtended by such process, but this less developed than those of basal segments. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Fourth legs (Fig. 20) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite inserted on medial free portion of distal border of segment. Basipodite with small lateral seta; medial margin with row of cilia. Exopodite, with somewhat medial flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 2 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 4 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal

margin, except for slight notch, entire. Trimerous endopodite with medial flexure. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines set in steplike emarginations, 1 terminal spine, 1 medial seta. Medial setae of distal segment very short. Each of basal 2 segments produced at distal lateral corner as small spinous cuticular process. Basal spine of terminal segment also subtended by such process. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges, complete in lateral spines, only on lateral margin of terminal spine. All setae of leg with plumose ciliation.

Fifth legs (Fig. 21) with probably 2 segments represented, basal consisting only of expansion on body segment posteriorly and laterally to furnish articulation of distal segment, with 1 small seta representing armature. Second segment elongate, flattened, with cuticularized medial and lateral margins. Length about 1.8 times greatest width. Armature 3 spines and 1 seta, spines about equally spaced on lateral and terminal margins: 1 lateral spine at distal corner of lateral margin; 1 spine at about midpoint of broad apical margin; 1 spine at medial distal corner; 1 seta near medial distal spine. Seta and apical spine subtended by small groups of spinules. Spinules also forming short rows on distal half of medial margin and middle third of lateral margin.

Sixth legs probably represented by small setiferous knob in depression at aperture of oviduct, located dorsally on lateral expansion of genital segment. Two subequal setules forming armature.

Caudal ramus (Fig. 22) about 2.5 times as long as greatest width and about as long as anal segment. Armature 6 setae. Of apical quartet of setae, medial of central 2 longest, about 4 times as long as ramus; adjacent long seta 2 times length of ramus. Medial apical seta about .6 as long as ramus; lateral apical seta about .4 as long as ramus. Lateral marginal seta short, about .4 as long as ramus, inserted on lateral margin at about distal third. Dorsal medial seta very short, inserted just subapically.

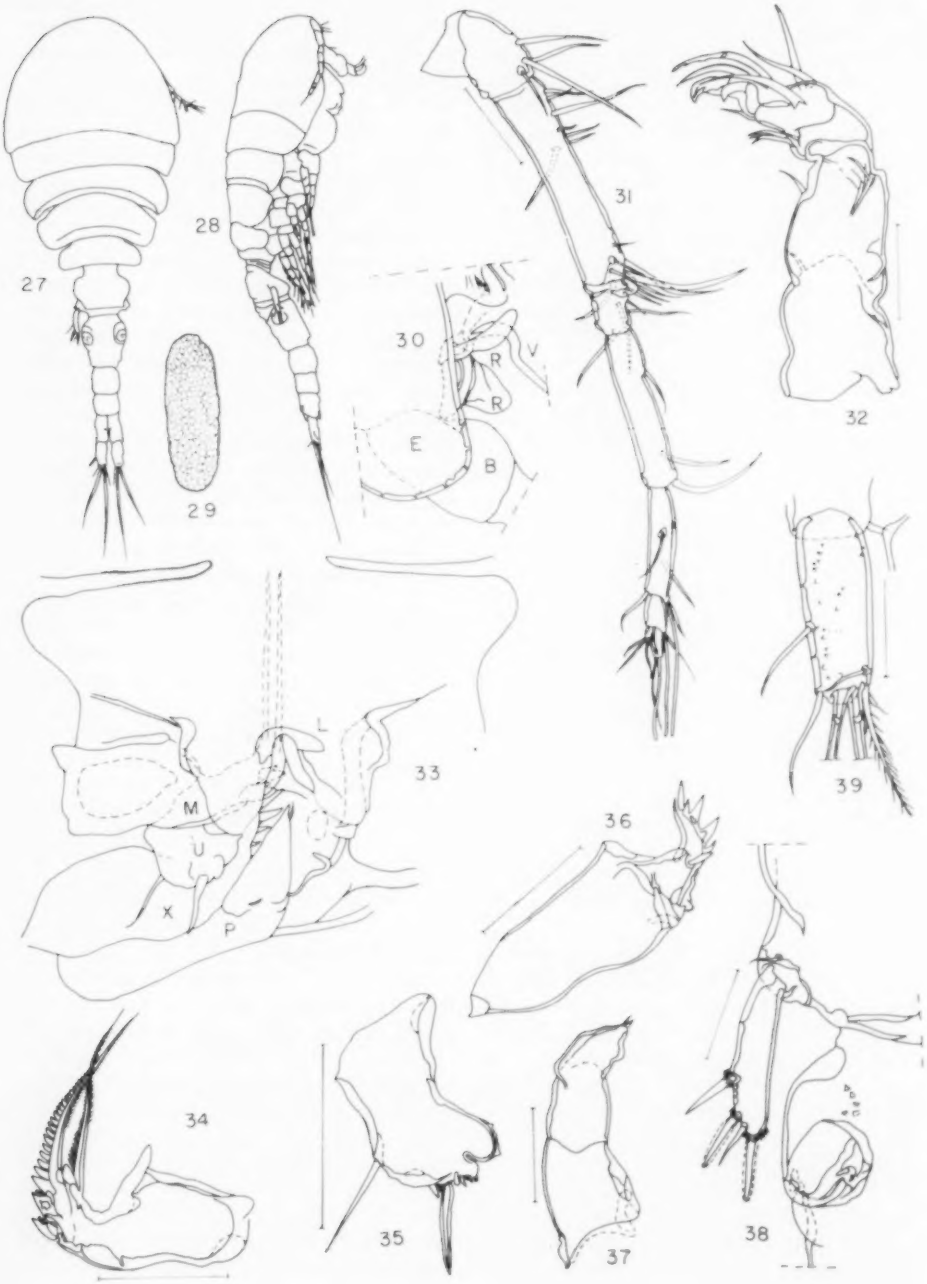
MALE (Figs. 23–26): Body length 1.5 mm., greatest width .5 mm., based on Wilson's original description. Body very generalized cyclopoid in type. Cephalosome bearing first legs, its segment indicated by slight marginal indentations. Metasome of free segments of legs 2 to 4. Urosome of free segments of legs 5, 6, and 4 abdominal segments, including segment bearing anus and caudal rami. Segments of legs 5 and 6 much coalesced in a genital complex (Fig. 23) accommodating spermatophores which are very elongate.

Antennules, antennae and mouthparts, except maxilliped, as in female. Maxillule (Fig. 24) of characteristic type of the genus; elongate, with shoe-shaped apex. A long medial seta and subapical spine. Two subequal small apical lobes.

Maxilliped (Fig. 25) highly dimorphic, developed as massive, complicated appendage, probably trimerous. In mouth area, maxillipeds held in characteristic posture, tending to align along longitudinal axis of body, second segment moving in sagittal plane over first segment, and terminal segment tending to swing in frontal plane. First segment about one-third length of second, unornamented. Second segment tapered apically, margin medial in position in normal posture of appendage bearing characteristic ornamentation, serving to act in conjunction with clawlike terminal segment in prehensile function. Medial ornamentation consisting of 2 longitudinal multiple rows of denticles, and a single row of long spinules. In addition, near midpoint of medial margin a short, stout spine. Terminal segment forming very complicated region of articulation on apex of second segment, prolonged as curving claw, longer than second segment. One seta inserted on expanded region of articulation.

Dimorphism also expressed particularly in first legs, remaining swimming legs very similar to those of female. Protopodites and exopodites of first legs essentially as in female. Basal segments of endopodites as in female, terminal segment of each with lateral spine, 1 apical spine, 1 apical seta, 3 medial setae, apical spine representing a seta of female appendage.

Fifth leg (Fig. 26) not greatly like that of female in outline, but with similar ornamentation. Length about 2.5 times greatest width, thus a much narrower appendage, without con-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spicuous basal constriction. Medial row of spinules more extensive, reaching apex.

Sixth legs (Fig. 23) ventrolateral on genital segment, involved in very complicated manner with structure of reproductive opening. Most obviously representative of appendage a small prominence bearing 2 setae, the more medial about half as long as lateral.

REMARKS: The species seems to belong to a southern California fauna, as it was collected from at least two localities, Anaheim Slough and Laguna Beach, by the MacGinities. In considerable exploration and study of marine zoology on the West Coast no collections from further north have yet come to my attention, although the host is recorded as ranging very widely on the coast of California and has been closely observed frequently. Details of the antennules should be reinvestigated on freshly collected specimens.

Anthessius lighti, new species
Figs. 27–58

TYPES: Holotypic female, USNM 103307, allotypic male, USNM 103308, paratypes, USNM 103309; additional paratypes in Alan Hancock Foundation, University of Southern California, and in author's collection. Type locality, Bodega Bay, California, from *Aplysia californica* Cooper.

SPECIMENS EXAMINED: Several lots of this species are included in the material studied, but as far as can be determined they represent a single collection from *A. californica*, from Bodega Bay, California, June 1, 1941, O. Hartman and E. C. Dougherty, many specimens, males and females. The descriptions below and the illustrations are based on a number of specimens, some unmounted, some whole mounts, some temporarily mounted dissections, some permanently mounted dissections. Two of the latter have been selected as holotype and allotype.

DESCRIPTION: Female (Figs. 27–43): Body length 2.67 mm., greatest width 1.14 mm., averages for 10 specimens. Body (Figs. 27, 28) of rather generalized cyclopoid contours, but with most thoracic and abdominal segments distinct, so that regionalization is not emphatic. Cephalosome a complex bearing appendages through first swimming legs and comprising .33 of total body length measured from apex of cephalosome to end of a caudal ramus. General contour and internal structure strongly indicating segment of leg 1 a part of cephalosome, but this segment clearly demarcated dorsally and anteriorly by continuous articulationlike groove and well-developed marginal indentations. Ventrally segment of leg 1 apparently contributing to cephalosome in forming massive midventral bulge between mouthparts and leg 1. First legs situated on posterior edge of segment, directed posteriorly, obviously behaving functionally as part of metasomal group of legs. On anterior margin apex of head protruded in a slight bulge between bases of widely separated antennules. No rostrum, apical ventral region of head a wide flattened expanse between bases of antennules and antennae. Metasome including pedigerous segments of second through fourth legs, with general body articulation between segments of legs 4 and 5. Segment of fourth legs with distinctive bilateral, ventral structures. Fourth legs borne on anterior end of ventral surface of segment. At each side on posterior region of ventral surface two subequal lobes extending posteriorly. Lobes visible in dorsal view (Fig. 30) of intact animal, as lying between segments of legs 4 and 5 and medial to the fourth legs. Urosome a complex including segment of legs 5, a genital segment and 3 additional abdominal segments, considering element bearing anus and supporting caudal rami as terminal segment. Segment of fifth leg, as in other pedigerous segments, with dorsal epimeralike lateral expansions. Urosome comprising .45 of total body length. Genital segment expanded laterally, dorsally with dis-

FIGS. 27–39: *Anthessius lighti*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 27, habit, dorsal; 28, habit, lateral; 29, egg sack; 30, lateral part of segment of fourth leg and adjoining structures, dorsal view; 31, antennule; 32, antenna; 33, oral area; 34, mandible; 35, maxillule; 36, maxilla; 37, maxilliped; 38, fifth leg and lateral portion of genital segment; 39, caudal ramus. Legend: *B*, base of fourth leg; *E*, epimeron of segment of fourth leg; *L*, labrum; *M*, mandible; *P*, maxilliped; *R*, protuberance of unknown significance at base of fourth leg; *U*, maxillule; *V*, segment of fifth leg; *X*, maxilla.

tinctive structures marking apertures of oviducts and sites of attachment of egg sacks (Fig. 38). Egg sack (Fig. 29) about .35 of total body length, containing several hundred small eggs.

Antennule (Fig. 31) essentially 7-segmented, but with complicated articulation and integumental modification between second and third segments, so as to suggest either coalescence or incipient separation of an additional minute segment. Approximate proportional lengths of segments, basal to distal: Segment I, 3; II, 7; III, 1.5; IV, 5; V, 3.5; VI, 1; VII, 1. Setae, varying in length and count per segment: Segment I, 4 setae; II, 7 setae near base of segment, 8 around distal end; III, 5 setae, 1 belonging to section suggesting a free segment; IV, 3 setae; V, 4 setae, 1 aesthete; VI, 2 setae, 1 aesthete; VII, about 5 setae, 3 on basal prominence of segment, apparently 2 setae and 1 aesthete apical.

Antenna (Fig. 32) with segmental composition obscured by flexures, involving integumental folds, and torsions, probably 3-segmented. Basal segment with partial distal articulation, 1 short external seta apically. Second segment with very complicated distal articulation, 1 short seta distally and externally inserted. Terminal segment short, with cuticularized ridges and folds and with very broad distal margin furnishing insertion for 4 elaborately articulated clawlike elements and 2 large setae. Another larger seta inserted midway between group of claws and apical setae. Small seta at external distal corner. A subapical group of 4 small setae of diverse lengths. Total elements: 4 claws, 8 setae.

Mouthparts compactly and intricately arranged in oral area (Fig. 33). Labrum of 2 conspicuous lobes, overlying entirely blades of mandibles, and much of distal parts of maxillae.

Mandible (Fig. 34) a flat, unsegmented plate, with cuticularized anterior and posterior margins. Appendage terminating in long lashlike blade with complicated marginal ornamentation. Two most basal elements of ornamentation flat platelike structures, compound apically and articulating with margin of appendage. Remainder of ornamentation a long row of graduated denticles, about 15 of them of conspicuous size. On anterior margin articulated a long lashlike auxiliary seta with conspicuous marginal ornamentation. All of outer margin bearing graduated row of spinules, distal two-thirds of inner margin with short spinules. Between apical lash and auxiliary seta a small articulated cuticular piece, subtriangular in outline.

Maxillule (Fig. 35) of characteristic type for the genus, an elongate lobe with flaring apex. On apex a spine and far laterally a seta. A medial apical indentation setting off a blunt median subapical lobe. Margins of appendage much sclerotized. Apical spine subtended by cuticular spinous processes and spinules.

Maxilla (Fig. 36) with very long diagonal articulation with body surface, resulting in characteristic basal segment, on which articulates flattened apical segment, with heavily cuticularized margins. Apex produced in sharp angle anteriorly with toothlike expansions of cuticle forming a medial saw-edge. Four large teeth formed by flangelike protrusions of cuticle. Apex produced as very small spinelike processes, 1 on each side of most distal tooth. Inserted at base of angle of curvature of this segment and lying on surface, an articulated, short, stout spine.

Maxilliped (Fig. 37) fairly long, a prominent mouthpart, as seen in general habitus of mouth area (Fig. 33), but with little development of segmentation or ornamentation. Three segments suggested by folds and flexures of integument. Basal 2 segments not ornamented. Terminal segment with 2 apical setules.

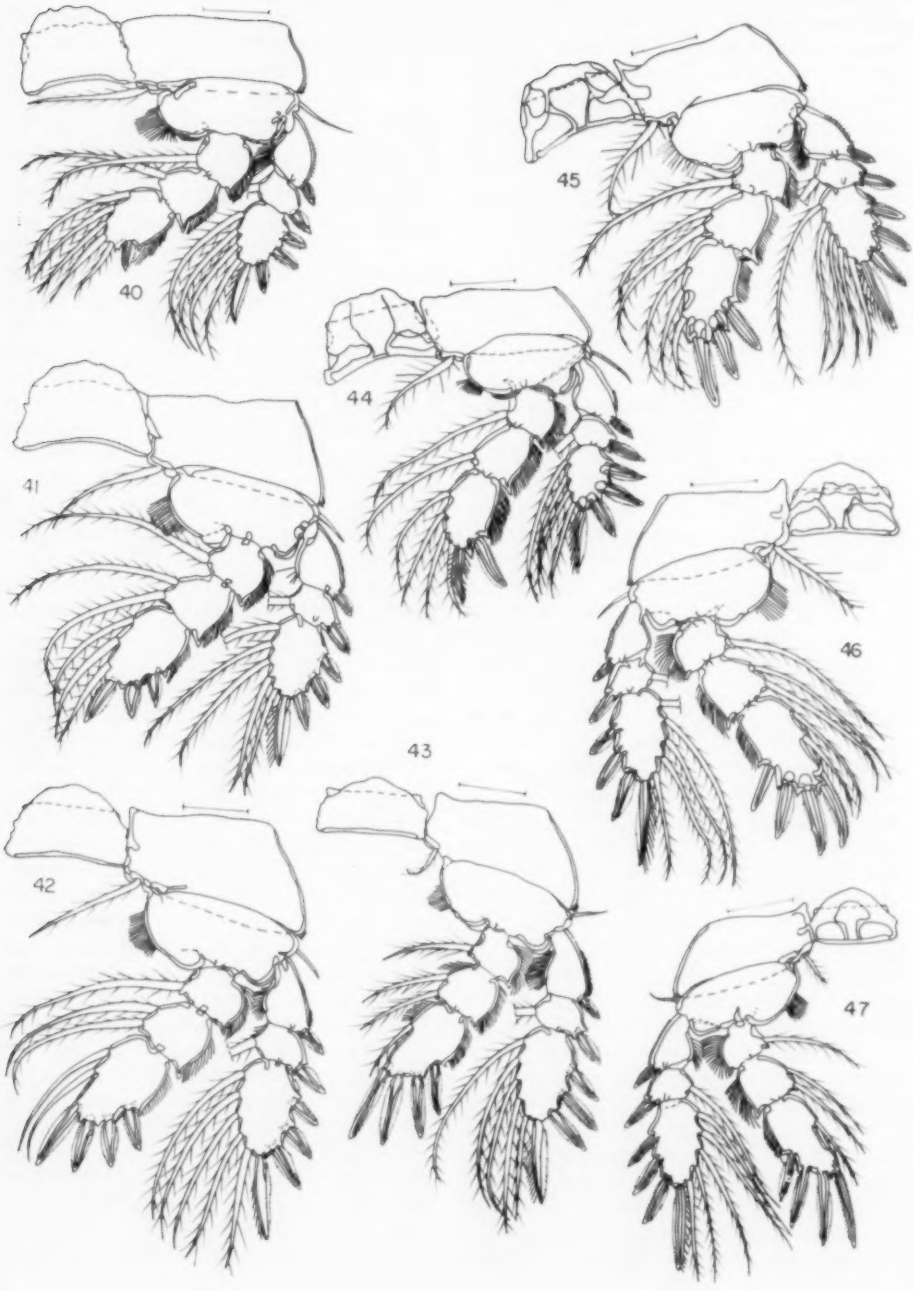
First legs (Fig. 40) with well-developed bimerous protopodites, yoked by substantial intercoxal plate. Basal width of basipodite less than width of distal margin of coxopodite, so medial seta of coxopodite inserted on free portion of margin. Small spinules forming ornament on lateral distal corner of coxopodite. Coxopodite seta relatively long, extending medially, and with its length equal to width of intercoxal plate. Basipodite with lateral seta proximal to insertion of exopodite and with dense row of cilia on curving medial margin. Exopodite, extending directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 3 medial setae. First segment with fine spinules on lateral margin, dense row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate

hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 1 medial seta; third segment, 1 lateral spine, set in distinct emargination, 2 apical setae, 3 medial setae. Each segment with row of cilia on lateral margin. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spine of terminal segment subtended by such process, and with outlining hyaline flange. All setae of leg with plumose ciliation.

Second legs (Fig. 41) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite on medial free portion of border of segment. Seta about as long as width of intercoxal plate. A few spinules at lateral distal corner of coxopodite. Basipodite with lateral seta, medial margin with dense row of cilia. Exopodite, extended directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, a few cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in steplike emarginations, 1 terminal spine, 3 medial setae. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spines of terminal segment subtended by such processes, but these less developed than those of basal segments. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Third legs (Fig. 42) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite, about as long as width of plate, inserted on medial free portion of distal border of segment. A few spinules at distal lateral corner of coxopodite. Basipodite with small lateral seta; medial margin with dense row of cilia. Exopodite, extended directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, dense row of cilia on medial margin. Second segment with a few cilia on proximal part of medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Trimerous endopodite slightly flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines, set in steplike emarginations, 1 terminal spine, 2 medial setae. Each of 2 basal segments produced at distal lateral corners as moderately spinous cuticular process. Spines of terminal segment subtended by such processes, but these less developed than those of basal segments. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Fourth legs (Fig. 43) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite small, inserted on somewhat diagonally directed medial free portion of distal border of segment. A few spinules at distal lateral corner of coxopodite. Basipodite with small lateral seta; medial margin with short, dense row of cilia. Exopodite, extended directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Trimerous endopodite with very slight medial flexure. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines set in steplike emarginations, 1 terminal spine, 1 medial seta. Medial setae of all segments reduced, that of distal segment very short. Each of basal 2 segments produced moderately at distal lateral corner as small spinous cuticular process. Spines of terminal segment subtended by such proc-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esses, these less well developed than those of basal segments. Each segment with dense row of cilia on lateral margin, distal 2 segments with medial cilia. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Fifth legs (Fig. 38) with probably 2 segments represented, basal consisting only of expansion on body segment posteriorly and laterally to furnish articulation of distal segment, but with 1 small seta representing armature. Second segment elongate, flat, with cuticularized medial and lateral margins. Length about 4 times greatest width. Armature 3 spines and 1 seta, spines about equally spaced on lateral and terminal margins: 1 lateral spine at about distal three-fourths of lateral margin, 1 lateral spine at about distal .9 of margin; 1 seta inserted close to lateral distal spine; 1 apical spine at medial distal corner. Spines subtended by small groups of spinules and cuticular spinous processes. Spinules of apical spine extending briefly on medial margin to form short row.

Sixth legs probably represented by small setiferous knob (Fig. 38) in depression at aperture of oviduct, located dorsally on lateral expansion of genital segment. Two subequal setules forming armature.

Caudal ramus (Fig. 39) about 2.6 times as long as greatest width and nearly as long as anal segment. Margins with conspicuous cuticular development and some surface ornamentation. Armature consisting of 6 setae. Of apical quartet of setae, medial of central 2 longest, about 3.5 times as long as ramus, adjacent seta 2.2 times length of ramus. Medial apical seta about .73 times as long as ramus; lateral apical seta about .55 times as long as ramus. Lateral marginal seta about .5 as long as ramus, inserted on lateral margin at about distal .6. Dorsal seta short, not quite as long as width of ramus, inserted medially just subapically.

MALE (Figs. 44–58): Body length 2.53 mm., greatest width 0.94 mm., based on 6 specimens. Body (Figs. 48, 49) very generalized cyclopoid in type. Cephalosome bearing first legs, segment of these appendages strongly indicated by indentations. Metasome of free segments of legs 2 to 4. Segment of leg 4 lacking auxiliary lobelike elements seen in female. Urosome of segments of legs 5, 6, and 4 abdominal segments. Segments of legs 5 and 6 much coalesced in a genital complex containing elongate spermatophores. Segment of leg 5 without epimera.

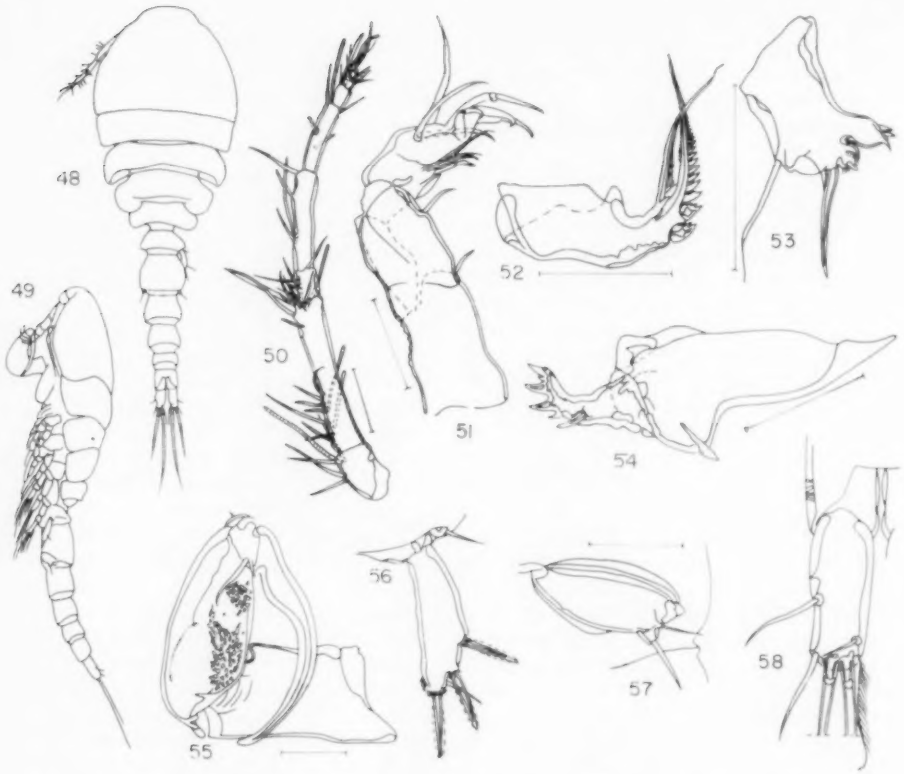
Antennule (Fig. 50) similar in proportions, segmentation and armature to that of female, but with dimorphism expressed in more highly developed aesthetes and greater number of aesthetes. Segment 2 has 2 conspicuous aesthetes accompanying basal group of 7 setae and 1 aesthete accompanying terminal group of 8 setae. Segment 4 has conspicuous aesthete accompanying 3 setae. In segments 5, 6, 7, aesthetes, corresponding to those of the female are present, but tending to be longer.

Antennae and mouthparts, except maxilliped, much as in female. Antenna (Fig. 51); mandible (Fig. 52); maxillule (Fig. 53); maxilla (Fig. 54).

Maxilliped (Fig. 55) highly dimorphic, developed as massive, complicated appendage, possibly trimerous. In mouth area, maxilliped held in characteristic posture. First segment not as long as second, unornamented. Second segment somewhat tapered apically, margin medial in position in normal posture bearing ornamentation serving to act in conjunction with clawlike terminal segment in prehensile function. Medial ornamentation consisting of patches of denticles. In addition, near midpoint of medial margin a short, stout spine. Terminal segment forming very complicated region of articulation on apex of second segment, prolonged as curving claw, longer than second segment. One seta, accompanied by 1 setule, inserted on expanded region of articulation.

Dimorphism also expressed particularly in first legs, remaining swimming legs very similar to those of female. Protopodites and exopodites of first legs (Fig. 44) essentially as in female. Basal segments of endopodites as in female, terminal segment of each with 1 lateral

FIGS. 40–47: *Anthessius lighti*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 40, first leg; 41, second leg; 42, third leg; 43, fourth leg. Male: 44, first leg; 45, second leg; 46, third leg; 47, fourth leg.



FIGS. 48–58: *Anthessius lighti*, new species. The scales accompanying certain figures represent 0.1 mm. Male: 48, habit, dorsal; 49, habit, lateral; 50, antennule; 51, antenna; 52, mandible; 53, maxillule; 54, maxilla; 55, maxilliped; 56, fifth leg; 57, sixth leg; 58, caudal ramus.

spine, 1 apical spine, 1 apical seta, 3 medial setae, apical spine representing a seta of the female appendage. Leg 2 (Fig. 45), leg 3 (Fig. 46), leg 4 (Fig. 47) in general aspect and ornamentation essentially similar to female.

Fifth leg (Fig. 56) very similar to that of female in general structure and ornamentation. Shorter in proportion to width, length equalling about 3 times greatest width.

Sixth legs (Fig. 57) ventrolateral on genital segment, involved in very complicated manner with structure of reproductive opening. Most obviously representative of appendage a small prominence bearing 2 setae, the more medial with an articulating base.

Caudal rami (Fig. 58) with no striking differences from those of female.

REMARKS: This species is named for S. F. Light. The species is distinguished from others of the genus in the key above. Some of its distinctive features may turn out to occur in other species when more anatomical details are known in the genus. The complement of aesthetes on the antennule of the male does not occur in *A. nortoni* and *A. fitchi*, also West Coast forms, but is found in *A. arenicolus* and *A. teissieri* of Europe. The accessory protuberances of the fourth pedigerous segment have not so far been reported from any other species.

Anthessius nortoni, new species
Figs. 59–91

TYPES: Holotypic female, USNM 103304, allotypic male, USNM 103305, paratypes, USNM 103306; paratypes in author's collection. Type locality, San Juan Island, Washington, from *Diadora aspera* (Eschscholtz).

SPECIMENS EXAMINED: From *D. aspera:* Culver's Point, San Juan Island, Washington, intertidal, July 5, 1952, many specimens, females, males, developmental stages, including holotype, allotype. Off Reed Rock, San Juan Channel, Washington, dredged, 92 m., July 2, 1953, many specimens, females, males, developmental stages. Salmon Beach, Tacoma Narrows, Washington, intertidal, May 14, 1953, many specimens, females, males.

The description below and the illustrations are based on a number of specimens, some unmounted, some whole mounts, some temporarily mounted dissections, some permanently mounted dissections. Holotype and allotype are permanently mounted dissections.

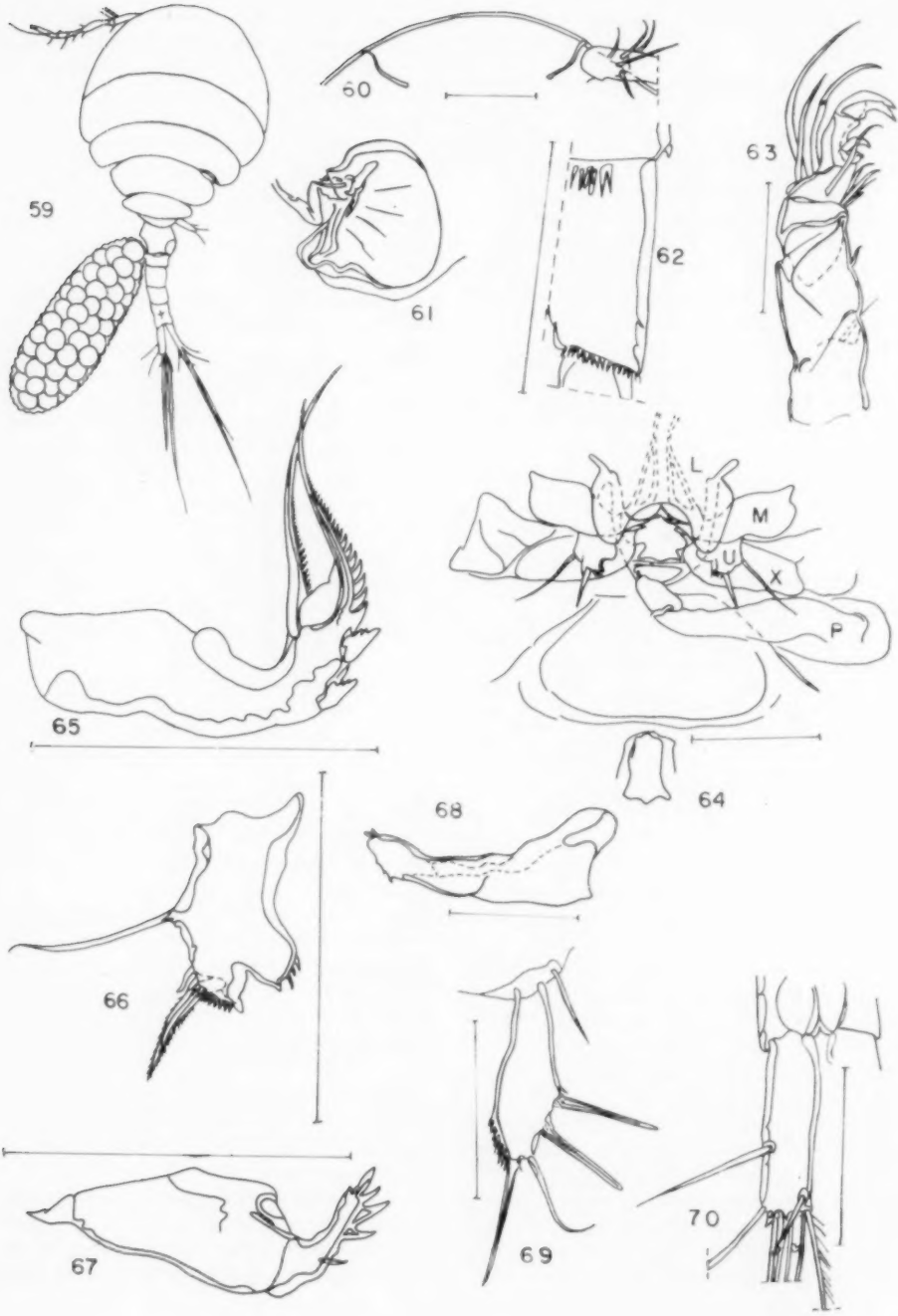
DESCRIPTION: Female (Figs. 59–75): Body length 1.28 mm., greatest width .63 mm., averages from 10 specimens. Body (Fig. 59) broad, of rather generalized cyclopoid contours, with thoracic and abdominal regionalization fairly emphatic. Cephalosome a complex bearing appendages through first swimming legs and comprising .34 of total body length, measured from apex of cephalosome to end of a caudal ramus. Segment of first legs strongly indicated by indentations and grooves, but mass of segment firmly coalesced with more anterior mass of body. Cephalosome and metasome together comprising a forebody of almost circular outline. On anterior margin, apex of head protruded as slight bulge between bases of widely separated antennules (Fig. 60). No rostrum, apical ventral region of head a wide flattened expanse between bases of antennules and antennae. Metasome including pedigerous segments of second through fourth legs, with general body articulation between segments of legs 4 and 5. Urosome a complex including segment of legs 5, genital segment and 3 additional abdominal segments, considering element of anal opening and supporting caudal rami as terminal segment. Urosome comprising .4 of total body length. Genital segment expanded laterally, dorsally with distinctive structures marking apertures of oviducts and sites of attachment of egg sacks (Fig. 61). Last abdominal segment with double row of spinules at midline on anterior ventral surface and with spinule rows on margins subtending each caudal ramus (Fig. 62). Egg sack about .6 as long as body, much exceeding tip of caudal ramus. Many small eggs in each egg sack.

Antennule (Fig. 71) essentially 7-segmented, but with a complicated articulation and integumental modification between second and third segments, so as to suggest either coalescence or incipient separation of an additional minute segment. Proportional lengths of segments, basal to distal: Segment I, 1.5; II, 3; III, 1; IV, 3; V, 2; VI, 1; VII, 1. Setae varying in length; count per segment: Segment I, 4 setae; II, 7 setae near base of segment, 8 around distal end; III, 5 setae, 1 belonging to section suggesting a free segment; IV, 3 setae; V, 4 setae, 1 aesthete; VI, 2 setae, 1 aesthete; VII, 7 setae and 1 aesthete, 4 setae on basal prominence of segment, 3 setae and aesthete apical.

Antenna (Fig. 63) short and stout, with segmental composition much obscured by flexures involving integumental folds and torsions of one region of appendage on adjoining regions, probably essentially 3-segmented. Basal segment fairly clear-cut, apical articulation diagonal, 1 short external seta apically. Second segment with very complicated distal articulation, this proceeding diagonally across appendage; 1 short seta externally inserted. Terminal segment with cuticularized ridges and folds and with very broad distal margin furnishing insertion for 4 elaborately articulated clawlike elements, varying much in size, and 2 setae. Another seta near distal margin. A subapical group of 4 setae of diverse lengths. Total elements: 4 claws, 7 setae.

Mouthparts compactly and intricately arranged in oral area (Fig. 64). Labrum of 2 conspicuous lobes, overlying entirely blades of mandibles, and much of distal parts of maxillae.

Mandible (Fig. 65) a flat plate, with very cuticularized anterior and posterior margins. Appendage terminating in long lashlike blade with complicated marginal ornamentation: Two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most basal elements of ornamentation flat toothlike structures, compound apically and articulating with margin of appendage; remainder of ornamentation a long row of graduated denticles, about 15 of them of conspicuous size. On anterior margin articulated a long lashlike auxiliary seta with outer margin bearing graduated row of spinules on proximal third; inner margin without spinules. Between apical lash and auxiliary seta a subtriangular cuticular piece, flat and platelike.

Maxillule (Fig. 66) of characteristic type of the genus, an elongate plate with lobed apex. On apex a spine; at midpoint of lateral margin a seta. An apical indentation setting off a blunt median subapical lobe. Margins of appendage much sclerotized. A few spinules on median lobe and row of graduated spinules subtending apical spine.

Maxilla (Fig. 67) with very long articulation with body, resulting in characteristic basal segment, on which articulates flattened apical segment, with heavily cuticularized margins. Apex produced in sharp angle anteriorly with toothlike expansions of cuticle forming a medial sawedge. Four large teeth formed by flangelike protrusions of cuticle. Inserted at base of angle of curvature of this segment and lying on surface, a small, articulated spine.

Maxilliped (Fig. 68) fairly long, a prominent mouthpart, as seen in general habitus of mouth area, but with little development of segmentation or ornamentation. Three segments suggested by folds and flexures of integument. Terminal segment with 2 apical setules. Margins cuticularized and produced into 2 spinulelike protrusions.

First legs (Fig. 72) with well-developed bimerous protopodites, yoked by substantial intercoxal plate. Basal width of basipodite less than width of distal margin of coxopodite, so medial seta of coxopodite inserted on free portion of margin. Small spinules forming ornamentation on lateral corner of coxopodite. Coxopodite seta very long, extending rather medially and distally, and with its length more than width of intercoxal plate. Basipodite with long lateral seta proximal to insertion of exopodite and with row of cilia on distal margin. Exopodite with slight medial flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 3 medial setae. First segment with large spinules on lateral margin, row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 1 medial seta; third segment, 1 lateral spine, set in distinct emargination, 1 lateral seta, 1 apical seta, 3 medial setae. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spine of terminal segment subtended by such process, and with outlining hyaline flange. Each segment with row of cilia on lateral margin. All setae of leg with plumose ciliation.

Second legs (Fig. 73) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite on medial free portion of border of segment. Seta about as long as width of intercoxal plate. A row of spinules at distal lateral corner of coxopodite. Basipodite with short lateral seta; terminal margin with rows of cilia. Exopodite trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of stout spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in steplike emarginations, 1 terminal spine, 3 medial

FIGS. 59–70: *Anthessius nortoni*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 59, habit, dorsal; 60, ventral apical region of cephalosome; 61, structures at genital aperture; 62, one side of anal segment showing ornamenting spinules; 63, antenna; 64, oral area; 65, mandible; 66, maxillule; 67, maxilla; 68, maxilliped; 69, fifth leg; 70, part of anal segment and caudal ramus. Legend: *L*, labrum; *M*, mandible; *P*, maxilliped; *U*, maxillule; *X*, maxilla.

setae. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Spines of terminal segment subtended by such processes, but these much less developed than those of basal segments. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Third legs (Fig. 74) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite, slightly longer than width of plate, inserted on medial free portion of distal border of segment. A few spinules at distal lateral corner of coxopodite. Basipodite with lateral seta; terminal margin with rows of cilia. Exopodite, extended directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Trimerous endopodite flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines, set in steplike emarginations, 1 terminal spine, 2 medial setae. Each of 2 basal segments produced at distal lateral corner as moderately small, spinous cuticular process. Spines of terminal segment subtended by such processes, but these less developed than those of basal segments. Each segment with dense row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

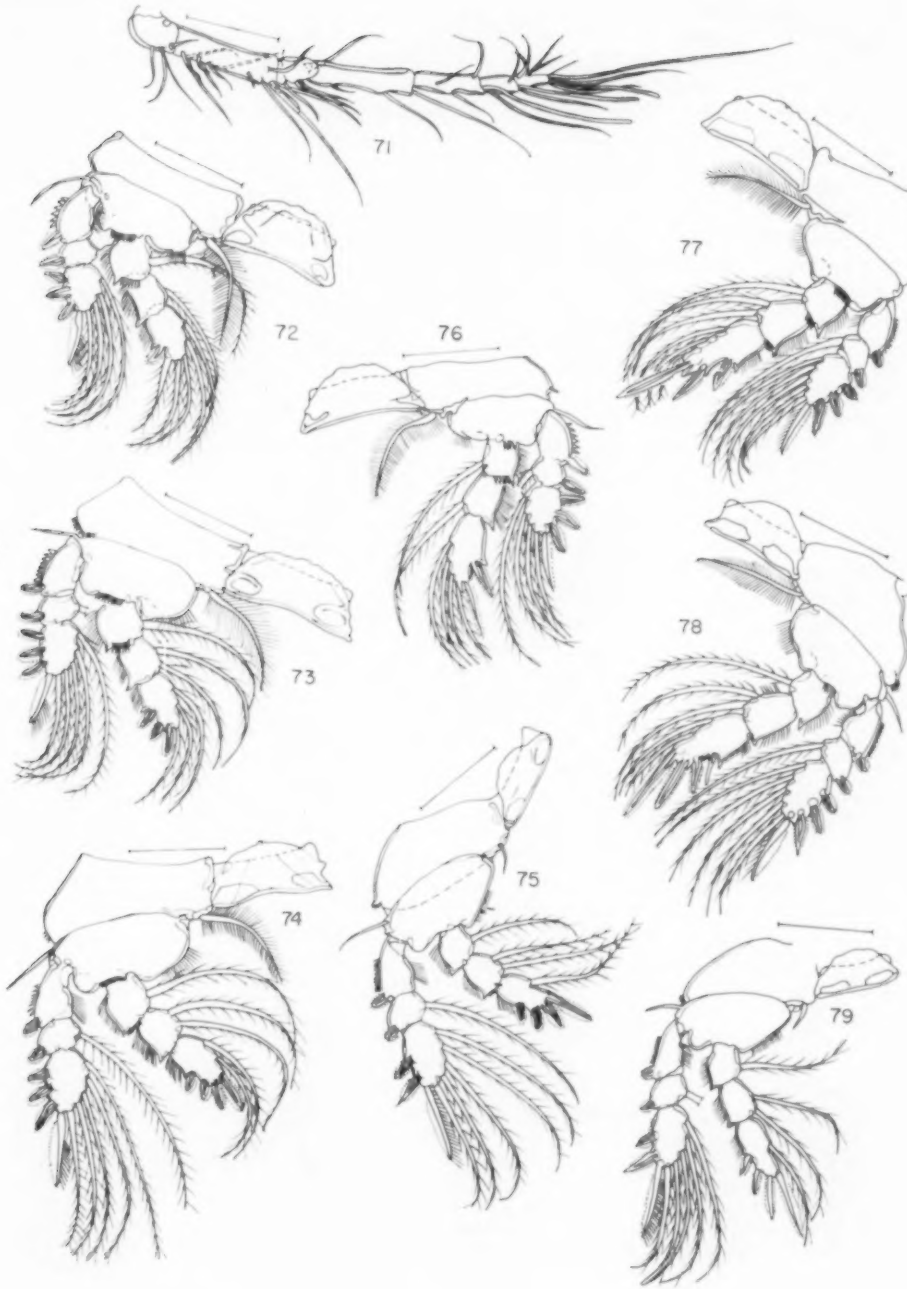
Fourth legs (Fig. 75) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Medial seta of coxopodite very small, inserted on somewhat diagonally directed medial free portion of distal border of segment. A few spinules at distal lateral corner of coxopodite. Basipodite with small lateral seta, medial margin with row of cilia. Exopodite, extended directly, without notable flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 2 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of spinules on lateral margin, cilia on medial margin. Proximal 4 spines of ramus each outlined with serrate, hyaline flange. Apical spine with external hyaline flange and internal row of cilia. Trimerous endopodite with very slight flexure. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines set in steplike emarginations, 1 terminal spine, 1 medial seta. Each of basal 2 segments produced moderately at distal lateral corner as small spinous cuticular process. Each spine of terminal segment subtended by such process, these less well developed than those of basal segments. All segments with dense rows of cilia on lateral margins. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Fifth legs (Fig. 69) with probably 2 segments represented, basal consisting only of expansion on body posteriorly and laterally on segment of legs to furnish articulation of distal segment, but with 1 small seta representing armature. Second segment elongate, flattened, with cuticularized medial and lateral margins. Shape highly distinctive, basal fourth much constricted, with abrupt flare to level of first spine. Length about 3.2 times greatest width. Armature 3 spines and 1 seta, about equally spaced on lateral and terminal margins: 1 lateral spine at about distal .7 of lateral margin, 1 lateral spine at about distal .8 of margin; 1 seta at lateral distal corner; apical spine at medial distal corner. Spines subtended by small groups of spinules. Short row of spinules on distal fourth of medial margin.

Sixth legs probably represented by small setiferous knob (Fig. 61) in depression at aperture of oviduct, located dorsally on lateral expansion of genital segment. One small setule forming armature.

Caudal ramus (Fig. 70) about 3 times as long

FIGS. 71–79: *Anthessius nortoni*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 71, antennule; 72, first leg; 73, second leg; 74, third leg; 75, fourth leg. Male: 76, first leg; 77, second leg; 78, third leg; 79, fourth leg.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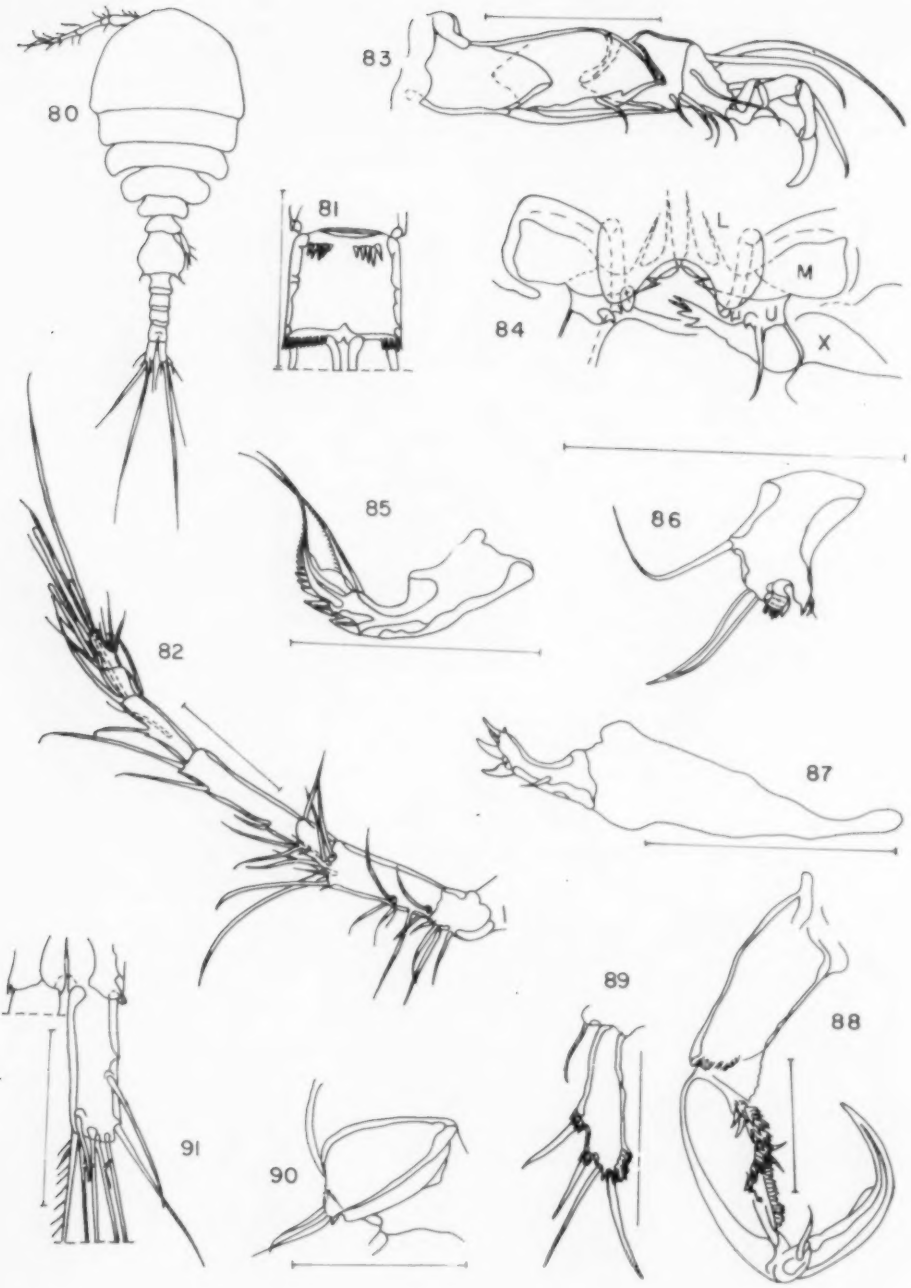
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as greatest width and 1.2 times as long as anal segment. Margins with conspicuous cuticular development. Armature 6 setae. Of apical quartet of setae, medial of central 2 longest, about 6.3 times as long as ramus, adjacent seta 3.5 times length of ramus. Medial apical seta about 1.6 times as long as ramus; lateral apical seta about .8 times as long as ramus. Lateral marginal seta short, about .7 times as long as ramus, inserted on lateral margin about at distal .6. Dorsal medial seta short, about as long as width of ramus, inserted just subapically.

MALE (Figs. 76–91): Body length 1.25 mm., greatest width .56 mm., averages from 10 specimens. Body (Fig. 80) very similar to that of female in size and aspect, but approaching a little more closely to generalized cyclopoid type. Cephalosome bearing first legs, segment of these indicated by very slight marginal indentations. Metasome of free segments of legs 2 to 4. Urosome of segments of legs 5, 6, and 4 abdominal segments, including element bearing anus and caudal rami. Segments of legs 5 and 6 much coalesced to form a genital complex, through which extend elongate spermatophores. Ornamentation of anal segment (Fig. 81) much as in female.

Antennule (Fig. 82) similar in proportions, segmentation and armature to that of female, no particular dimorphism expressed.

Antennae and mouthparts, except maxilliped as in female. Antenna (Fig. 83); oral area (Fig. 84); mandible (Fig. 85); maxillule (Fig. 86); maxilla (Fig. 87).

Maxilliped (Fig. 88) highly dimorphic, developed as massive, complicated appendage, probably trimerous. First segment about as long as second, with row of fine spinules on distal margin. Second segment somewhat tapered apically, margin medial in position of normal posture of appendage bearing characteristic ornamentation serving to act in conjunction with clawlike terminal segment in prehensile function, this consisting of patches of long denticles. In addition, near midpoint of medial margin 2 short, stout spines. Terminal segment forming very complicated region of articulation on apex of second segment, prolonged as curving claw, longer than second segment. One seta inserted on expanded region of articulation with segment 2.

Dimorphism also expressed particularly in first and third legs, remaining swimming legs very similar to those of female. Protopodites and exopodites of first legs essentially as in female. Basal segments of endopodites as in female, terminal segment of each with lateral spine, 1 apical spine, 1 apical seta, 3 medial setae, very long apical spine representing a seta of female appendage (Fig. 76). Leg 2 (Fig. 77) in general aspect and ornamentation essentially similar to that of female. Leg 3 (Fig. 78) showing slight dimorphism in that most proximal lateral spine of terminal segment of endopodite has characteristic shape, a basal knob, angled posture, and lacks outlining hyaline flange of other spines of rami. Leg 4 (Fig. 78) as in female.

Fifth leg (Fig. 89) very similar to that of female in general structure. Length about 3 times greatest width. Accessory ornamentation of spinules more highly developed than in female.

Sixth legs (Fig. 90) ventrolateral on genital segment, involved in very complicated manner with structure of reproductive opening. Most obviously representative of appendage a small prominence bearing 2 unequal setae, the more medial with a well-developed articulating base.

Caudal rami (Fig. 91) very similar to those of female.

REMARKS: This form is named for John R. Norton. The species occurs very commonly in association with its typical host in Washington Sound, Puget Sound, and also on the outer rocky ocean coast of Washington, in the Cape Flattery Region. The usual infestation consists of fair numbers of the copepod, ranging to several dozen. They wander freely in the rather capacious respiratory cavity of the host, sometimes emerging from the dorsal aperture or moving over the foot and other fleshy parts. They are

FIGS. 80–91: *Anthessius nortoni*, new species. The scales accompanying certain figures represent 0.1 mm. Male: 80, habit, dorsal; 81, anal segment; 82, antennule; 83, antenna; 84, oral area; 85, mandible; 86, maxillule; 87, maxilla; 88, maxilliped; 89, fifth leg; 90, sixth leg; 91, part of anal segment and caudal ramus. Legend: *L*, labrum; *M*, mandible; *U*, maxillule; *X*, maxilla.

usually readily detected if the host is held in sea water for observation. There has been no interaction so far detected between the copepod and the other extremely commonly occurring associate of *D. aspera*, the polynoid worm *Arctonoë vittata* (Grube). The large limpets of the genus *Acmaea*, living in the same environment as the host, sometimes will be found to have a specimen of *A. nortoni* in the respiratory cavity, but I feel that present evidence does not justify considering this as a regularly occurring association. The typical host should be further explored for this associate over its considerable range; I suspect the copepod will be found to have a wide distribution. This is one of the very small species of *Anthessius*, and in many regards it shows resemblance to the common European *A. arenicolus* and *A. teissieri*. However, it is distinctive anatomically, as expressed in part in the key to species above. It is the first member of the genus so far reported in association with an aspidobranch gastropod.

Anthessius fitchi, new species
Figs. 92–125

TYPES: Holotypic female, USNM 103301, allotypic male, USNM 103302, paratypes, USNM 103303; paratypes in author's collection. Type locality, Carpinteria, California, from *Chaceia ovoidea* (Gould).

SPECIMENS EXAMINED: From *C. ovoidea:* Carpinteria, California, November 11, 1954, J. E. Fitch, many specimens, females, males, including holotype and allotype.

Carpinteria, California, January 1, 1956, J. E. Fitch, 50 + specimens.

From *Zirfaea pilsbryi* Lowe: Fossil Point, Coos Bay, Oregon, July 23, 1959, 1 ♀.

The description below and the illustrations are based on a number of specimens, some unmounted, some whole mounts, some temporarily mounted dissections, some permanently mounted dissections. Holotype and allotype are permanently mounted dissections.

DESCRIPTION: Female (Figs. 92–102, 104–110): Body length 5.8 mm. (5.6–6.1), greatest width 2.1 mm. (2.0–2.3), based on 10 specimens. Body (Fig. 92) of this gigantic species of most distinctive habitus, retaining only general overall cyclopoid contours. Salient characteristics of habitus consist in much expanded outline of cephalosome, elongate antennules, much expanded lateral winglike epimera of thoracic segments, lateral expansions of genital segment, elongate and distally widened anal segment, and elongate, flattened and widened caudal rami. Not continuously present on adults, but of such distinctive nature as to contribute to definite aspect of characteristic habitus, elongate stringlike egg sacks and persistently attached stalked spermatophores. Cephalosome a fused complex bearing appendages through first swimming legs without any demarcation of segment of these latter. Cephalosome comprising .25 of total body length. Apically a slight protrusion between bases of antennules. Ventrally, area between antennular bases somewhat bulged and outlined by cuticular thickenings, but not developed as a proper rostrum (see Fig. 117 for this feature in male). Metasome of 3 pedigerous segments, each with widely flaring lateral winglike epimera, those of first metasomal segment much the widest, those of next 2 segments successively diminishing. Urosome a complex including segment of legs 5, genital segment and 3 additional abdominal segments, considering element bearing anal opening and caudal rami as terminal segment. Urosome comprising .55 of total body length. Segment of fifth legs (Fig. 102) lacking epimera, but with lateral expansions of entire mass of segment. Anterior and posterior margins of segment of about same width, greatest lateral extent about 2.33 times width of anterior margin. Each lateral protrusion also somewhat inflated, with resultant structures extending almost to center of segment. Fifth legs inserted apically on each expansion. Genital segment also of very distinctive outline, with two widely extending lateral ex-

FIGS. 92–103: *Anthessius fitchi*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 92, habit, dorsal; 93, antennule; 94, antenna; 95, oral area; 96, labrum and supporting structure of oral area with appendages removed; 97, mandible; 98, maxillule; 99, maxilla; 100, maxilliped; 101, apex of maxilliped; 102, segment of fifth legs, dorsal. Male: 103, habit, dorsal. Legend: *L.* labrum; *M.* mandible; *P.* maxilliped; *U.* maxillule; *X.* maxilla.

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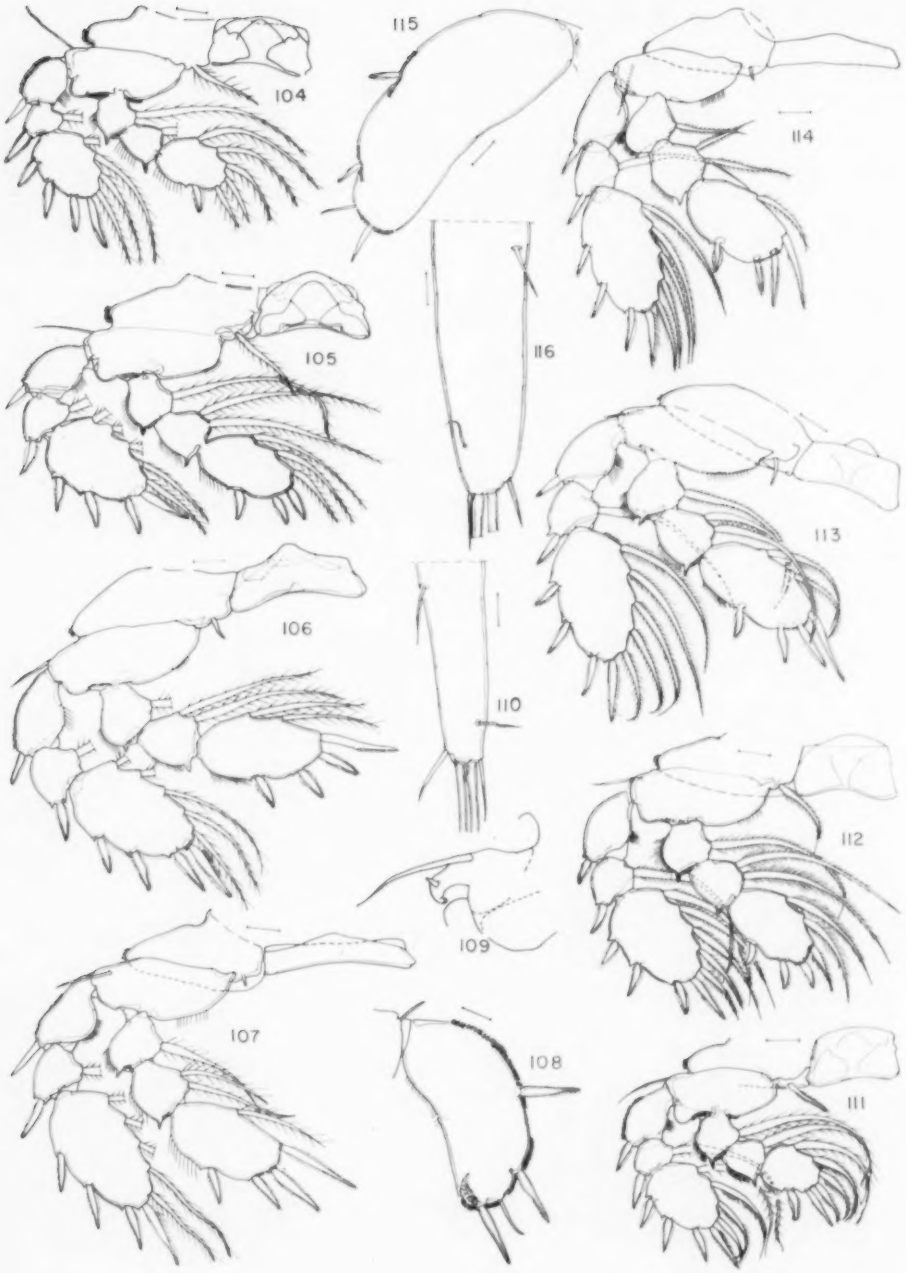
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pansions. Anterior and posterior margins of segment about equal width, greatest lateral extent over 3 times width of anterior margin. Median mass of segment not notably intruded on by reproductive structures, these occupying most of each strong lateral protrusion. Dorsally on each lateral process 1 or 2 spermatophores usually seen in persistent attachment. Each spermatophore elongate, ovoid, length about 3 times greatest width, with gradual taper to apical filiform attachment stalk, about .3 times as long as spermatophore proper.

Elongate egg sacks, about .75 as long as the body and with width only .05 length, hence of pronounced filiform aspect, attaching near posterior margin of each process of genital segment.

In remainder of urosome anterior 2 of 3 abdominal segments subequal, much smaller than anal segment. Latter almost 2 times as long as next anterior and with distinctive flaring outline, greatest width, just subterminal, 1.5 times width of anterior margin of segment.

Antennule (Fig. 93) long, somewhat flattened, 7-segmented, fifth segment with notable expansion of outline. Approximate proportional lengths of segments, basal to distal: Segment I, 2.5; II, 4; III, 1; IV, 3.3; V, 2.7; VI, 1.7; VII, 1.4. Setae varying in length. Count of setae, per segment: Segment I, 4 setae; II, 7 setae near base of segment, 8 around distal end; III, 5 setae; IV, 3 setae; V, 4 setae, 1 aesthete; VI, 2 setae, 1 aesthete; VII, 6 setae, 3 on basal prominence of segment, 3 setae and 1 aesthete apical.

Antenna (Fig. 94) with segmental composition much obscured by flexures, involving integumental folds, and torsions of regions of appendage, probably essentially 3 segments. Basal segment not clearly defined, apical articulation incomplete, 1 short external seta apically. Second segment with very complicated distal articulation, this proceeding diagonally across appendage; 1 short seta on external margin. Terminal segment with cuticularized ridges and folds and with very broad distal margin furnishing insertion for 4 elaborately articulated clawlike elements and 2 setae. Another seta near distal margin. A subapical group of 4 setae of diverse lengths. Total elements: 4 claws, 7 setae.

Mouthparts compactly and intricately arranged in oral area (Fig. 95). Labrum with 2 lobes, overlying blades of mandibles. Basal structures of labrum complex, associated with other sclerotized pieces located postorally, to form an intricate mouth apparatus (Fig. 96).

Mandible (Fig. 97) a flat plate, with very cuticularized anterior and posterior margins. Appendage terminating in long lashlike blade with complicated marginal ornamentation. Most basal elements of ornamentation flat platelike structures articulating with margin of appendage. Remainder of ornamentation a long graduated row of denticles. On anterior margin of mandible articulated a long lashlike auxiliary seta with conspicuous marginal cuticularization. Basal two-thirds of outer margin bearing graduated row of spinules. Between apical lash and auxiliary seta a flat cuticular piece with indented distal margin, forming an outer lobe with acuminate apex and an inner lobe with rounded terminal outline.

Maxillule (Fig. 98) of characteristic type for genus, an elongate lobe with flaring apex. On apex a more medial spine and very long lateral seta. A medial apical indentation setting off a blunt medial subapical lobe. Margins of appendage much sclerotized, produced into spinelike cuticular processes apically and on medial lobe.

Maxilla (Fig. 99) with very long articulation with body, resulting in characteristic basal segment, on which articulates flattened apical segment, with heavily cuticularized margins. Apex produced in sharp angle anteriorly with toothlike expansions of marginal cuticle forming a medial saw-edge. Five to 7 large teeth formed by flangelike protrusions of cuticle. Apex produced as more elongate spinelike process. Inserted at base of angle of curvature of this segment and lying on surface, a stout, short articulated spine.

FIGS. 104–116: *Anthessius fitchi*, new species. The scales accompanying certain figures represent 0.1 mm. Female: 104, first leg; 105, second leg; 106, third leg; 107, fourth leg; 108, fifth leg; 109, sixth leg; 110, caudal ramus. Male: 111, first leg; 112, second leg; 113, third leg; 114, fourth leg; 115, fifth leg; 116, caudal ramus.

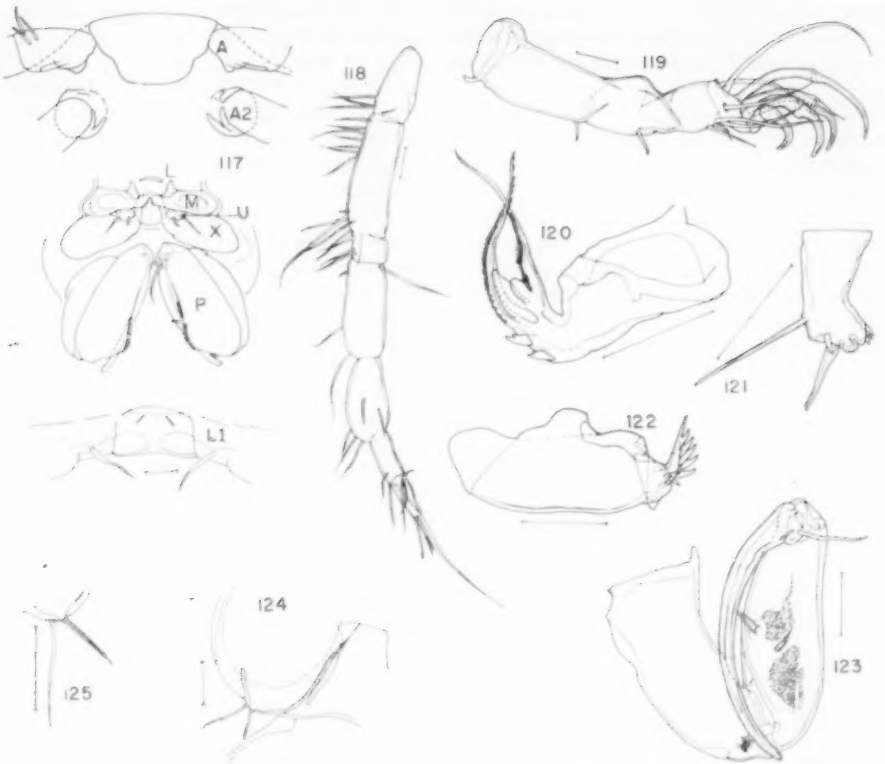
Maxilliped (Fig. 100) fairly long, a prominent mouthpart, as seen in general habitus of mouth area, but with little development of segmentation or ornamentation. Three segments suggested by folds and flexures of integument. Basal segment fairly well defined, unornamented. Second segment ornamented with 1 marginal setule and an arching row of spinules. Terminal segment with 2 apical setules and an interrupted row of spinules on the surface (Fig. 101). Margin cuticularized and produced into 2 or more spinulelike protrusions.

Legs 1 to 4 very characteristic for the species and unlike those of any other form so far described in the genus in marked flattening and exaggerated development of terminal segments of rami as broad laminae. Armature and ornamentation essentially identical with that of other species. A peculiar type of cuticular ornament distributed over various body elements, seemingly highly distinctive for the species. Each element of this ornamentation apparently a small cylinder with flat end, the whole of fairly soft consistency and protruding like a tube from surface of body. A large number of these over ventral surfaces of wide epimeral expansions of cephalosome, a few on each epimeron of metasomal segments, a few on each basipodite, some on terminal segment of each ramus of each leg, some on fifth leg, fairly large numbers forming rows down middle of surface of each caudal ramus.

First legs (Fig. 104) with well-developed bimerous protopodites, yoked by substantial intercoxal plate. Basipodite laterally offset on coxopodite, so medial seta of coxopodite inserted on free portion of terminal margin. Coxopodite seta extending rather more medially than distally, and with its length slightly less than width of intercoxal plate. Distal lateral corner of coxopodite with row of spinules. Basipodite with small lateral seta proximal to insertion of exopodite and with short rows of cilia on distal margin. Exopodite trimerous; armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 3 medial setae. First segment with fine spinules on lateral margin and row of cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate hyaline flange. Apical spine with external entire hyaline flange and internal row of cilia. Endopodite flexed medially and proximally, trimerous. Armature: first segment, 1 medial seta; second segment, 1 medial seta; third segment, 1 lateral spine, set in slight emargination, 2 apical setae, 3 medial setae. Three most distal setae reduced in length. Each of basal 2 segments of ramus produced at distal lateral corner as spinous cuticular process. Spine of terminal segment subtended by minute spinous process, and with outlining hyaline flange. Each segment with row of cilia on lateral margin. All setae of leg with plumose ciliation.

Second legs (Fig. 105) with well-developed bimerous protopodites yoked by substantial intercoxal plate. A row of spinules at distal lateral corner of coxopodite. Medial seta of coxopodite on medial free portion of border of segment. Seta about as long as width of intercoxal plate. Basipodite with long lateral seta; terminal margin with rows of cilia. Exopodite, flexed and at angle to protopodite, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with apical hyaline flange and internal row of cilia. Endopodite flexed medially and proximally, trimerous. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 2 lateral spines, set in slight emarginations, 1 terminal spine, 3 medial setae. Setae of terminal segment progressively reduced. Each of 2 basal segments produced at distal lateral corner as spinous cuticular process. Basal spine of terminal segment subtended by such process, but this much less developed than those of basal segments. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Third legs (Fig. 106) with well-developed bimerous protopodites yoked by substantial intercoxal plate. Small medial seta of coxopodite inserted on medial free portion of distal border of segment. A few spinules at distal lateral corner of coxopodite. Basipodite with lateral seta;



FIGS. 117–125: *Anthessius fitchi*, new species. The scales accompanying certain figures represent 0.1 mm. Male: 117, ventral view of mid-region of cephalosome; 118, antennule; 119, antenna; 120, mandible; 121, maxillule; 122, maxilla; 123, maxilliped; 124, sixth leg and reproductive aperture; 125, setae of sixth leg. Legend: *A*, antennule; *A2*, antenna; *L*, labrum; *L1*, base of first leg; *M*, mandible; *P*, maxilliped; *X*, maxilla.

terminal and medial margins with rows of cilia. Exopodite, with medially curving flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with apical hyaline flange and internal row of cilia. Trimerous endopodite slightly flexed medially and proximally. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines, set in slight emarginations, 1 terminal spine, 2 medial setae. Setae of terminal segment reduced. Each of 2 basal segments produced at distal lateral corner as moderately small spinous cuticular process. Basal spine of terminal segment subtended by such process, but less developed than those of basal segments. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges, apical spine with flange only on distal lateral margin. All setae of leg with plumose ciliation.

Fourth legs (Fig. 107) with well-developed bimerous protopodites yoked by widely extending, short proximal to distal, intercoxal plate. Medial seta of coxopodite very small, inserted on medial free portion of distal border of seg-

ment. A few spinules at distal lateral corner of coxopodite. Basipodite with lateral seta. Exopodite with slight flexure, trimerous. Armature: first segment, 1 lateral spine; second segment, 1 lateral spine, 1 medial seta; third segment, 3 lateral spines, 1 terminal spine, 1 terminal seta, 4 medial setae. First segment with row of fine spinules on lateral margin, cilia on medial margin. Proximal 5 spines of ramus each outlined with serrate, hyaline flange. Apical spine with apical flange and internal row of cilia. Trimerous endopodite with medial flexure. Armature: first segment, 1 medial seta; second segment, 2 medial setae; third segment, 3 lateral spines set in emarginations, 1 terminal spine, 1 medial seta. Medial setae of all segments reduced, that of distal segment very short. Each of basal 2 segments produced moderately at distal lateral corner as small spinous cuticular process. Each spine of terminal segment subtended by such process, these less well-developed than those of basal segment. Each segment with row of cilia on lateral margin. Spines of terminal segment with hyaline flanges. All setae of leg with plumose ciliation.

Fifth legs (Fig. 108) with probably 2 segments represented, basal involved in expansion on segment of body posteriorly and laterally to furnish articulation for distal segment, with 1 small seta representing armature. Second segment elongate, very wide, flattened, with cuticularized medial and lateral margins. Length about 2 times greatest width. Armature 3 spines and 1 seta, spines about equally spaced on lateral and terminal margins: 1 lateral spine at about distal half of lateral margin, 1 lateral spine at about distal .9 of margin; apical spine at medial distal corner. Short, slender seta between terminal 2 spines, somewhat closer to apical spine. Spines subtended by small groups of spinules. A row of spinules on proximal third of medial margin and a row on most of lateral margin. Several short rows of spinules forming dense patch at apical medial corner.

Sixth legs probably represented by setiferous curving process (Fig. 109) at aperture of oviduct, located dorsally on lateral expansion of genital segment. Armature 1 relatively well-developed seta and 1 short, tapered, stout spinule.

Caudal ramus about 4.5 times as long as greatest width and about 2 times as long as anal segment. Shape most characteristic, a flat lamina expanding to greatest width at about proximal third, gradually tapering to apex, which is half as wide as greatest width. Margins with conspicuous cuticular development. Armature 6 setae (Fig. 110). Of apical quartet of setae, medial of central 2 longest, about .8 times as long as ramus, adjacent seta about .4 times length of ramus. Medial apical seta about .16 times as long as ramus; lateral apical seta about .16 times as long as ramus. Lateral marginal seta short, about .7 times as long as ramus, inserted slightly proximal to midpoint of lateral margin. Dorsal medial seta short, slender, about .1 times length of ramus, inserted subapically, at about distal .9 of ramus. Length of caudal ramus 1.1 mm. (1.0–1.1) and greatest width .23 mm. (.20–.25), averages for 10 specimens.

MALE (Figs. 103, 111–125): Body length 6.0 mm. (5.6–6.2), greatest width 2.1 mm. (1.9–2.3), averages from 10 specimens. Body shape (Fig. 103) of same distinctive form as that of female, slightly larger overall, with larger fifth legs and larger caudal rami. Cephalosome equivalently expanded in outline, without superficial indication of included segment of first legs. Antennules elongated and flattened. Cephalosome much the widest body region. Ventrally at apex a bulgelike protrusion (Fig. 117), not an actual rostrum. Three segments of metasome each with distinctive expanded lateral epimera, as in female. Urosome 6-segmented, very characteristic in structure, by enormous size of fifth legs, uniquely developed anal segment and caudal rami. Segments of legs 5 and 6 much coalesced in a genital complex containing elongate paired spermatophores. Segment of leg 5 widest segment of urosome, fifth legs borne far laterally and each lying along and parallel with margin of next posterior segments. Fifth leg reaching to middle of third urosomal segment. Segment of leg 6 longest segment of urosome, with some lateral expansion, this involving only very gradual taper from anterior margin of segment. Anal segment, as in female, with flaring outline, and supporting enormous, elongate, flattened caudal rami.

Antennule (Fig. 118) markedly similar in

proportions, segmentation and armature to that of female, all elements seeming to correspond in the two sexes. Antennae (Fig. 119) also like those of female.

Oral area (Fig. 117) with characteristic aspect, only differing from that of female because of great development of dimorphic maxillipeds, these appearing as most conspicuous element in complex of mouthparts.

Mandible (Fig. 120) essentially as in female, some minute differences in details of ornament, possibly as much expression of individual difference as of dimorphism. Maxillule (Fig. 121) almost exactly as in female. Maxilla (Fig. 122) as in female.

Maxilliped (Fig. 123) highly dimorphic, developed as massive, complicated appendage, apparently 3-segmented. First segment not as long as second, about .75 as long, unornamented, except for distal lateral clump of spinules. Second segment somewhat tapered apically, margin medial in position in normal posture of appendage bearing characteristic ornamentation serving to act in conjunction with clawlike terminal segment in prehensile function. Medial ornamentation consisting of dense patches of denticles. In addition, near midpoint of medial margin a short, stout spine and another spine at same level on inner surface of segment. Terminal segment forming very complicated region of articulation on apex of second segment, prolonged as curving claw, slightly longer than second segment. One long seta, accompanied by 1 setule, inserted on expanded region of articulation with segment 2.

Dimorphism expressed also in first legs, remaining swimming legs very similar to those of female. Protopodites and exopodites of first legs (Fig. 111) essentially as in female. Basal segments of endopodites as in female, terminal segment of each with lateral spine, 1 apical spine, 1 apical seta, 3 medial setae, the apical spine representing a seta of female appendage. Leg 2 (Fig. 112), leg 3 (Fig. 113), leg 4 (Fig. 114) in general aspect and ornamentation essentially similar to those of female.

Fifth legs (Fig. 115) only resembling those of female in general structure and ornamentation, but of different outline and proportionately much longer. Length equaling about 3 times greatest width. Distal spines and seta much more widely spaced than in female. Marginal ornamentation of spinules less developed than in female.

Sixth legs (Fig. 124) ventrolateral on genital segment, involved in very complicated manner with structure of reproductive opening. Most obviously representative of appendage a small prominence bearing 2 setae (Fig. 125), the more medial with well-developed articulating base.

Caudal rami similar in outline and general features to those of female, armature (Fig. 116) also corresponding, but rami of greater overall size and proportionately slightly wider in male. Length 1.3 mm. (1.2–1.4), greatest width .3 mm. (.295–.305), averages from 10 specimens.

REMARKS: The species is named for John E. Fitch. This gigantic copepod is by far the most distinctive form in the genus and stands much separated from all other species by the elaborate development of the body processes and the form of most appendages. Perhaps its unique habitus deserves greater taxonomic emphasis than specific designation, but I cannot see any additional information to be provided by the designation of a monotypic taxon for this form. Except for absolute size, the antennae and mouthparts are very consistent with those of other species. In the other appendages the numerical complement of segments and elements of armature are entirely the same as for other species, but in outlines and dimensions the structure remains unique. The typical host is a giant piddock, boring burrows in substantial rock. The copepods occur over the general body surface of the host and in its burrows, according to the collector. The distribution of this host is apparently a limited one. An indication of broader distribution of the copepod exists in the single specimen, collected in Oregon, 1959, from *Zirfaea*, a large boring mollusk, closely related to *Chaceia*.

SUMMARY: Five species of *Anthessius* are described in detail, two of these, *A. hawaiiensis* (Wilson) and *A. navanacis* (Wilson), being redescribed from type material. These occur in Hawaii and Southern California, respectively. New species described are *A. lighti* and *A. fitchi*

from California and *A. nortoni* from Washington. Hosts for these species are a nudibranch, *Pleurobranchus*, for *A. hawaiiensis*, tectibranchs, *Navanax* and *Aplysia*, for *A. navanacis* and *A. lighti*, a pelecypod, *Chaceia* for *A. fitchi*, and an aspidobranch gastropod *Diadora* for *A. nortoni*. These findings, added to previous records, increase the impression that the genus is composed of species characteristically associated with a variety of molluscan hosts.

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Hawaiian Lava-Flow Fishes, Part IV

Snyderidia canina Gilbert, with Notes on the Osteology of Ophidioid Families[1]

WILLIAM A. GOSLINE[2]

ALTHOUGH THE GENUS *Snyderidia* is well marked and well described, it has been assigned at one time or another to four different families. In the attempt to determine the proper family allocation of this genus, it has been necessary to reinvestigate the nature of the families of the suborder Ophidioidea to which it belongs.

The history of *Snyderidia* is as follows. The genus and species (*Snyderidia canina*) were described by Gilbert (1905: 654, 655) from a single specimen 309 mm. in length taken off Kauai of the Hawaiian Islands at a depth of 385–500 fathoms. Another specimen 122 mm. in length was taken by Gosline, Hayes, and Keen from among the fishes killed by the lava flow off Hawaii on June 6, 1950.[3] Gilbert's original description is excellent and applies well to the lava flow specimen. Indeed there is nothing worth adding, so far as external features are concerned. Parr (1933: 49), because of the squamation in *Brotulotaenia*, has suggested that small, embedded scales might be present in *Snyderidia*, but Gilbert is correct in stating that scales in the latter genus are absent.

Snyderidia was placed by Gilbert in the Lycodapidae, a family hitherto represented by the single genus *Lycodapus* from the west coast of North America. However, Regan places *Lycodapus* in the blennioid family Zoarcidae (1912: 276) with the statement:

> *Lycodapus*, Gilbert, includes small deep-sea fishes of the North Pacific, and has been made the type of a distinct family and placed near the Fierasferidae [Carapidae]. But the head and mouth recall those of *Lycodopsis* or *Bothrocara*, the gill-membranes join the isthmus between the rami of the lower jaw (at least in *L. fierasfer*), and the dorsal and anal rays correspond in number to the myotomes.

C. L. Hubbs (*in litt.*) concurs with Regan's placement of *Lycodapus* in the Zoarcidae. On the basis of these allocations I will assume that *Lycodapus* is a blennioid fish and dismiss it from further consideration. Inasmuch as the several dorsal and anal rays per vertebra indicate immediately that *Snyderidia* is not a blennioid, it cannot be placed in the same family with *Lycodapus*.

Smith and Radcliffe (in Radcliffe, 1913: 175) described *Pyramodon*, a genus very similar in appearance to *Snyderidia*, and placed both genera in the Carapidae.

However, Regan (1914: 20) included these genera in the Brotulidae with the following explanation:

> In many respects these two genera seem to connect the Brotulidae with the Fierasferidae, but I have ascertained that *Pyramodon* agrees with the Brotulidae in the structure of the upper surface of the skull, the supraoccipital separating the rather small parietals.

Smith (1955: 546) tentatively assigns *Snyderidia* to his family Pyramodontidae, which is distinguished as follows:

> I. Parietals small, separated by supraoccipital. Maxilla well expanded posteriorly. Usually pyloric caeca. Pelvics usually present. Pectorals normally with more than 20 rays.
>
> A. Dorsal origin well in advance of anal origin and vent, the latter behind pectoral origin. Scales usually present. Dentition feeble. Spines on opercular bones usually present. Preopercle margin usually free.....Brotulidae

[1] Contribution No. 135, Hawaii Marine Laboratory. Previous papers on these same collections of fishes were: I, The Origin and Nature of the Collections; II, Brotulidae; and III, Sternoptychidae. All of these previous sections were published in this journal.

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[3] A third specimen of this species is mentioned by Radcliffe (1913: 176), but he does not state where it was taken. Schultz and Kanazawa (*in litt.*) provide the information that this third specimen is USNM 99230, collected in the Philippines.

B. Dorsal origin opposite anal origin and vent, all far forward, at level of or not far behind pectoral origin. No scales. Dentition powerful, large canines. No opercular armature. Hind preopercle margin entirely below skin.....Pyramodontidae

II. Parietals moderate, meet on midline. Maxilla not or barely expanded posteriorly. Pelvics absent. Scales absent. Vent and anal origin usually anterior to dorsal origin. Pectorals with less than 20 rays.....Carapidae

Arnold's (1956) revision of the Carapidae contains no mention of either *Snyderidia* or *Pyramodon*.

In sum then, *Snyderidia* has been placed in the Lycodapidae, Carapidae, Brotulidae, and tentatively in the Pyramodontidae. As the first of these allocations is almost certainly erroneous, the problem that remains is to determine the relationship of *Snyderidia* to other ophidioid groups.

Aside from Smith's recent erection of the Pyramodontidae and the synonymizing of the Disparichthyidae with the Carapidae (see de Beaufort, 1951: 449; Arnold, 1956: 260, 261), the classification of the ophidioid fishes stems directly from Regan (1912). Three ophidioid families, distinguished by the characters listed in Table 1, were there recognized. So far as can be determined from Regan's paper, the internal features recorded are based on skeletons of a single species from each family: *"Brotula jayakari"* of the Brotulidae, *"Genypterus blacodes"* of the Ophidiidae, and *"Fierasfer acus"* of the Carapidae.

If these were small and uniform families one might allocate *Snyderidia* by simple reference to Table 1. However, the possibility of both internal and external diversity exists in all three and has been abundantly verified in the Brotulidae (cf. Norman, 1939: 83, 84; Gosline, 1953: 220–225). In view of this, it seems advisable to use a much broader base than Regan's for the establishment of family definitions among the ophidioid fishes. Unfortunately such a base is only partly available.

So far as the external features generally used are concerned, some members of the tremendous family Brotulidae nearly overlap the Ophidiidae, whereas others grade almost imperceptibly by way of Smith's Pyramodontidae into the Carapidae. Whether external characters exist in these families that would provide better definitions remains unknown to this author, for only a few forms are available for examination.

The present paper therefore will be concerned primarily with osteological features. Skeletons that have been used here are those of *Microbrotula*, *Dinematichthys*, and *Brotula* previously prepared (Gosline, 1953), of *Snyderidia*, and of a specimen of (presumably) *Otophidium*[4] (without data) received from the U. S. National Museum. The following literature on internal features has also been referred to: Emery (1880), Regan (1912), and Arnold (1956).

Cranium: Unlike the other crania at hand, that of *Snyderidia* is thin walled and rather fragile. The sutures in many instances—e.g., on the back of the skull, between the lower portion of the sphenotic and pterotic, and in the alisphenoid area—are difficult to make out, and in Fig. 1*a* and *b* some of these have been drawn with considerable misgiving.

Regan (1912) made use of three cranial characters in separating the Brotulidae from the Carapidae (Table 1, nos. 6–8). Two of these concern the development of the supraoccipital. According to Regan (1912) the parietals are

[4] In view of the varied interpretations of ophidiid genera (cf. Harry, 1951; Norman, ms., 1957) it seems advisable to give a brief description of the specimen skeletonized.

Total length 185 mm. Pelvics inserted about below the anterior border of the pupil, the outer filaments a little over twice as long as the inner. Gill membranes attached to the isthmus below rear border of eye. Four developed gill rakers. Pseudobranch consisting of about five short filaments. Head scaleless. No spine on snout tip. Opercle ending in a strong, concealed, little flattened spine. Anterior nostril on snout rim; posterior about midway between snout rim and anterior border of eye. Teeth many-rowed on jaws, vomer, and palatines, the rows tapering in width from front to rear. Outer jaw teeth rather long, curved, and sharply conical; inner similar but smaller, straighter, and blunter. Preorbital not differing greatly from suborbitals.

Scales on body rectangular, not embedded and not overlapping, the long axes of adjacent scales frequently at right angles to one another. Dorsal and anal rays covered with flesh, dark edged posteriorly and around tail. Air bladder short, terminating rather abruptly posteriorly, with a hole in its posteroventral face.

TABLE 1

DIFFERENCES BETWEEN OPHIDIOID FAMILIES NOTED BY REGAN (1912: 277–280)

BROTULIDAE	OPHIDIIDAE	CARAPIDAE
1. Pelvic fins, when present, jugular	Pelvic fins inserted between rami of lower jaw	Pelvics absent
2. Vent remote from head		Vent placed at throat
3. Gill openings wide, with gill membranes separate and free from isthmus (except in *Dermatopsis*)	Gill membranes attached to isthmus behind pelvics	
4. Mouth protractile		Mouth nonprotractile
5. Pterygoid and mesopterygoid separate	Pterygoid and mesopterygoid ankylosed	
6. Parietals separated by supraoccipital		Parietals meet above supraoccipital
7. Supraoccipital forms, with exoccipitals, a strong median crest which does not project above upper surface of skull		Occipital crest is weak, and exoccipitals do not take part in its formation
8. Opisthotic is not enlarged, though basioccipital and prootic form a rather prominent auditory bulla		Enlarged opisthotic reaches basioccipital, sharing with that bone and prootic in formation of auditory bulla
9. Lower fork of posttemporal is directly attached to opisthotic	Lower fork of posttemporal is shortened and attached to opisthotic by ligament	Lower fork of posttemporal is reduced to a little knob
10. Coracoid and scapula are separated by cartilage	Coracoid and scapula are in contact	Coracoid and scapula are in contact
11. Cleithra normal	Cleithra prolonged within isthmus as a pair of slender processes, with pelvic bones attached to their extremities	
12. Vertebrae (in *Brotula multibarbata*) 15 + 40	Vertebrae (in *Genypterus blacodes*) 20 + 52	Vertebrae (in *Carapus acus, fide* Emery) 125–144, of which 17 or 18 are precaudal; 26 precaudal vertebrae in *Carapus dentatus*
13. First 5 vertebrae with sessile ribs, 3rd and 4th pairs being expanded	First 5 vertebrae with sessile ribs, but only 3rd expanded	
14. Strong transverse processes on vertebrae 6–15	Parapophyses on vertebrae 6–11 are strong and broad, much as in *Merluccius;* rest are normal	

separated by the supraoccipital in the brotulids but meet above in the carapids. I have already shown (1953: 232) that *Dinematichthys*, among three brotulids examined, had the parietals meeting above. In *Otophidium* as well as in *"Ophidium Rochei"* (Emery, 1880, pl. 3, fig. 26) the parietals are separated by the supraoccipital. In *Pyramodon* (acc. Regan, 1914) they are separated, but in *Snyderidia* and the two carapids figured by Emery (1880, pl. 3, figs. 18, 23) they meet. Whether the parietals are separated or meet is correlated with the size of the occipital crest (Table 1, no. 7); among the skeletons available it would seem that the supraoccipital is best developed in the narrow, highheaded forms, e.g., *Otophidium* (Fig. 1*c*), and least developed in the broad, flatheaded species, e.g., *Dinematichthys*. That the size and extent of the supraoccipital have any great systematic value in this suborder seems questionable.

The relative size of the opisthotic (Table 1, no. 8) is another feature variable within the

brotulids (Gosline, 1953, table 3). The opisthotic of *Otophidium* (Fig. 1*c*) and *Snyderidia* (Fig. 1*b*) is expanded.

Three other cranial features of *Otophidium* and *Snyderidia* seem worth noting. In *Otophidium* the exoccipital facet for the articulation of the first vertebra forms a single concave wall of nearly uniform depth; in the available brotulids and in *Snyderidia* this articulation is formed by the usual two projecting pads. In *Snyderidia* I can find no trace of a suture between the frontals (Fig. 1*a*). Finally, in the same genus, as frequently in carapids, there is a greatly enlarged canine tooth at the front of the vomer (Fig. 1*b*).

Suspensorium: Regan (1912) has used the fusion vs. nonfusion of the ectopterygoid and mesopterygoid as a distinction between the Ophidiidae and the Brotulidae. In the three brotulid skeletons available the mesopterygoid and ectopterygoid are indeed joined by suture, whereas in the ophidiid they are fused. Emery (1880, pl. 3) shows the mesopterygoid and ectopterygoid of two species of carapids as suturally joined. In *Snyderidia* (Fig. 2) I have been able to find no trace of a suture between the ecto- and the mesopterygoid, but, as already noted, I have had difficulty locating the sutures between several of the other head bones in this specimen.

Another variable character in the ophidioid fishes is the position and size of the metapterygoid. In *Brotula* this bone completely separates the hyomandibula and mesopterygoid. In the other two brotulid skeletons, as in *Otophidium*, the latter two bones barely meet in front of the metapterygoid, and in *Snyderidia* (Fig. 2) there is a broad mesopterygoid-hyomandibula junction in front of the metapterygoid.

In *Snyderidia* (Fig. 2), as in *Otophidium*, the hyomandibular strut that runs back across the inner face of the preopercle to form the articulation with the opercle is long and narrow, not short and strong as in *Brotula*.

Opercular bones: The opercle in *Snyderidia* is formed of two struts extending out like the wings of a V from the opercle-hyomandibular articulation. The upper of these wings ends in a point; the lower is broadly rounded distally. The structure is not very different from that in

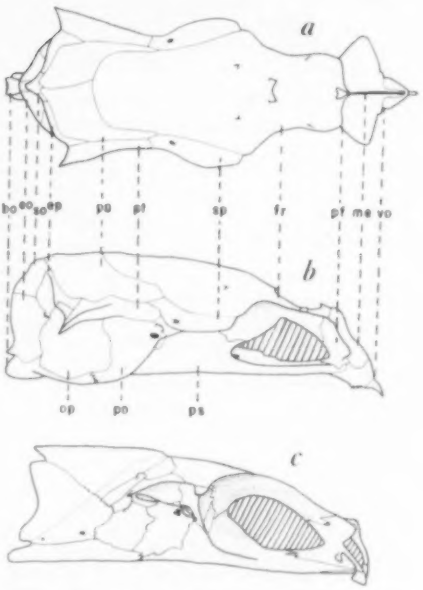

FIG. 1. Skulls of: *Snyderidia*. *a*, top view, *b*, side view; *c*, of *Otophidium*, side view. The dotted line in *c* represents the approximate limit of the occipital crest. *bo*, Basioccipital; *eo*, exoccipital; *ep*, epiotic; *fr*, frontals; *me*, mesethmoid; *op*, opisthotic; *pa*, parietal; *pf*, prefrontal; *po*, prootic; *ps*, parasphenoid; *pt*, pterotic; *so*, supraoccipital; *sp*, sphenotic; *vo*, vomer.

Otophidium or the illustrations of carapids given by Emery (1880, pl. 3).

Jaws: Except for the large canine tooth at the front of the premaxillary of *Snyderidia*, I am unable to find significant differences between it, *Otophidium*, and the three brotulid genera. The upper jaw of *Snyderidia* is about as drawn by Emery (1880, pl. 3, fig. 25) for "*Fierasfer dentatus*."

The lower jaw in carapids has been dealt with recently by Arnold (1956) who distinguishes three types within the family. The mandible of *Snyderidia* (Fig. 2) very definitely falls with type B of Arnold (1956, fig. 3; see also Emery, 1880, pl. 3, fig. 25). The lower double rim of this jaw type is also found in *Otophidium* but not in the available brotulid skeletons.

A curious feature of the lower jaw of *Snyderidia* is that in dissection the angular on both sides, together with its ligamentous attachment

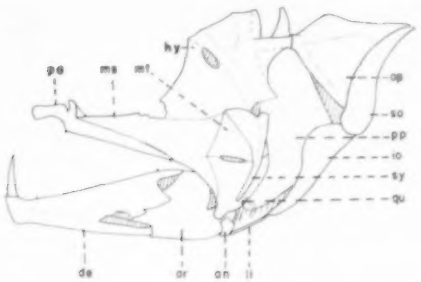

FIG. 2. Right suspensorium, mandible, and opercular bones of *Snyderidia*, from inside. Interosseous areas hatched. *an*, Angular; *ar*, articular; *de*, dentary; *hy*, hyomandibular; *io*, interopercle; *li*, ligament between angular and interopercle; *ms*, mesopterygoid and ectopterygoid; *mt*, metapterygoid; *op*, opercle; *pa*, palatine; *pp*, preopercle; *qu*, quadrate; *so*, subopercle; *sy*, symplectic.

to the interopercle (Fig. 2), came free from the rest of the jaw. Presumably it was loosely connected by ligament with the articular, rather than united with it by suture as in the other ophidioids available.

Visceral arches: The hyoid apparatus of *Snyderidia* seems to show no unusual features. There are seven branchiostegal rays: five on the ceratohyal and two on the epihyal. The urohyal is short and has the configuration of an inverted T.

The first gill arch in *Snyderidia* contains two rows of spinous patches. The outer row below contains about 13 spinous patches in front plus three elongate struts; the uppermost of these is at the angle. Each of these struts, i.e., developed gill rakers, has a whole series of spinelets projecting from its inner surface. On the upper portion of the gill arch (above the angle) there are 3 patches of spinelets in the outer row.

The basibranchial area between the bases of the 2nd gill arch and the pharyngeals consists of an elongate raised ridge with teeth. There are basibranchial teeth in some brotulids (cf. Gosline, 1954: 77, fig. 3), but none are present in those for which skeletons are available. The basibranchials of *Otophidium* are also toothless, but Emery (1880, pl. 5) shows basibranchial teeth in *"Fierasfer acus."*

In *Snyderidia* there are the usual pair of separate toothed lower pharyngeals and three pairs of toothed upper pharyngeals.

Regan has used the gill membranes as a character for separating most of the brotulids from the carapids (Table 1, no. 3). In *Snyderidia* Gilbert (1905: 654) states: "Gill-openings continued forward to below eye; gill membranes separate, free from isthmus." In this feature, and *Pyramodon* is similar, *Snyderidia* belongs with the brotulids.

Pectoral girdle and fin: The bones of the primary pectoral girdle are very light and difficult to make out. Apparently they are similar to those drawn for *"Fierasfer"* by Emery (1880, pl. 4, fig. 35). The coracoid and scapula are in contact, and there is a small scapular foramen.

Regan differentiates the Brotulidae from the other two ophidioid families in having the coracoid and scapula separated by cartilage. This is certainly true of *Brotula*. However, in *Dinematichthys* the scapula and coracoid seem to be nearly in contact (Fig. 3*b*). Be that as it may, the primary pectoral girdle is so poorly developed in all the ophidioid skeletons available that it would seem inadvisable to attach much importance to differences between them.

In the secondary pectoral girdle, Regan has used the structure of the posttemporal as a character for distinguishing families (Table 1, no. 9). However, the distinctiveness of the posttemporal structure as stated by Regan is greater than in the fishes. Whether the lower posttemporal limb articulates directly or by ligament with the opisthotic is difficult to determine in available skeletons; in all, the tip of the lower limb of the posttemporal closely approaches the opisthotic, but even in *Brotula* the main attachment between the two bones appears to be ligamentous.

There is indeed considerable differentiation among the relative sizes of the two posttemporal wings in the skeletons at hand. In *Brotula* both prongs are about equally long; in *Otophidium* the upper prong is nearly five times as long as the lower (Fig. 3*a*); the other brotulids and *Snyderidia* fall between *Brotula* and *Otophidium* in the relative lengths of the posttemporal wings.

Vertebral column: The vertebral column has perhaps been used more than any other internal structure in differentiating groups of ophidioid

fishes. In addition to the features noted by Regan (Table 1, nos. 11–14), various authors have noted the peculiar first vertebra of the Ophidiidae, and Arnold (1956) has recently discussed several aspects of the vertebral column in the carapids.

Posteriorly, the vertebral column of carapids and *Snyderidia* tapers to nothing, and there is no hypural fan (Emery, 1880, pl. 2). In brotulids, the caudal skeleton is quite variable, some species having a moderately well-developed hypural structure (Gosline, 1953, fig. 2b, which unfortunately is upside down); in others (Gosline, 1953, fig. 2a, c) no hypural fan whatever seems present. In *Otophidium* the caudal skeleton is about as in *Dinematichthys* (cf. Gosline, 1953, fig. 2b), i.e., moderately well developed.

At the anterior end the first vertebra shows considerable variation in the different ophidioids. For example, among the skeletons examined *Otophidium* has a rather more specialized method of articulation between the skull and the vertebral column than the others, and the neural arch of the first vertebra is heavy, with the two sides fused above, but low and rounded (Fig. 4*a*). In *Snyderidia* the two sides of the first neural arch extend up and back but are short and barely meet above. In the three brotulids (see Fig. 4*b*) the first neural arch has about the same inclination but is higher and is closely appressed against the second. In the carapids according to Emery (1880, pl. 5) and Arnold (1956) the first neural arch projects upward and forward.

One or more of the first few pairs of ribs in *Brotula*, *Otophidium* (cf. Müller, 1843; Facciola, 1933), and *Carapus* (cf. Emery, 1880) is closely associated with the air bladder. The nature of these first ribs has been used by Regan (Table 1, no. 13) to differentiate ophidioid families. In *Brotula* (Fig. 4*b*) and *Dinematichthys* the ribs on vertebrae one and two are sessile and unexpanded; in *Snyderidia* the first two ribs are sessile but somewhat expanded; in *Otophidium* the first vertebra and its ribs (Fig. 4*a*) are exceedingly specialized. In *Brotula* and *Dinematichthys* the ribs on the third and fourth vertebrae are separate, sessile and more or less expanded. In *Snyderidia* the rib on the third vertebra is sessile and considerably expanded but that of the fourth is minute and attached to a long parapophysis. In *Otophidium* the second vertebra seems to lack ribs; the third, fourth, and fifth have sessile ribs, of which that from the third runs medially to the air bladder.

As to the number of transverse processes (Table 1, no. 14), there is in *Otophidium*, at least, the probability that "transverse processes" and "sessile ribs" are actually the same structures, the distinction being merely one of definition, i.e., it would appear that in this fish a "transverse process" that has a basal articulation with the centrum becomes a "sessile rib" (cf. Emery, 1880, pl. 5, fig. 50, c_4). Nevertheless the old

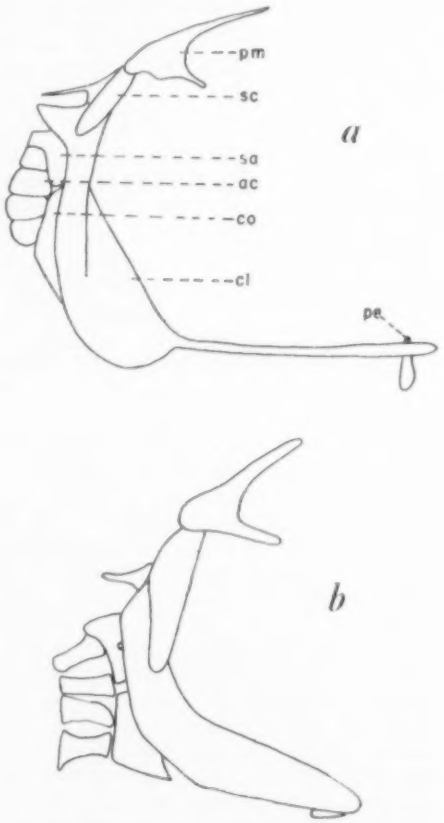

FIG. 3. Right pectoral girdles of, *a*, *Otophidium* and, *b*, *Dinematichthys*, from outside. *ac*, Actinost; *cl*, cleithrum; *co*, coracoid; *pe*, pelvic girdle; *pm*, posttemporal; *sa*, scapula; *sc*, supracleithrum.

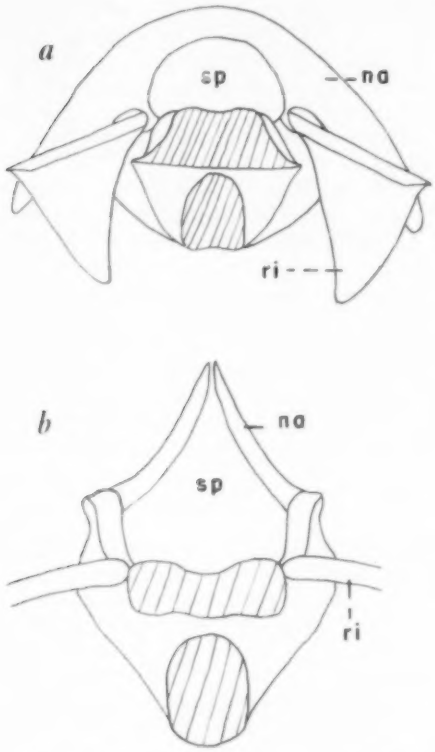

FIG. 4. First vertebra and ribs of, *a*, *Otophidium* and, *b*, *Brotula*, from front. Surfaces for articulation with skull hatched. *na*, Neutral arch; *ri*, rib; *sp*, space containing spinal cord.

terminology will be used in order to deal with character no. 13 of Table I. In *Brotula* the first five vertebrae have "sessile ribs"; in *Dinematichthys* the first six; in *Otophidium* the first, third, fourth, and fifth; and in *Snyderidia* the first three only. (In *Microbrotula* ribs are now lacking from several of the front vertebrae, but they may well have been lost in the process of skeletonization.) Judging from Emery's plate (1880, pl. 5) sessile ribs are present on the first four vertebrae of *"Fierasfer acus"* and *"Fierasfer dentatus"*; in the latter species each rib is separate, but in the former the ribs of vertebrae three and four have apparently fused into a single plate (see also Arnold, 1956, fig. 2c). According to Arnold (1956: 257, fig. 5) a third group of carapids has the transverse processes ("sessile ribs") of vertebrae three, four, and five fused into a single plate.

Regan has also used the number of "strong transverse processes" as a character for separating the brotulids from the ophidiids (Table 1, no. 14), but this is certainly a variable character in the brotulids. For example, *Microbrotula* has transverse processes only on vertebrae eight through eleven, whereas *Hypopleuron* (see Radcliffe, 1913, pl. 14) has greatly expanded parapophyses on vertebrae four to fourteen (which partly enclose the air bladder).

A final vertebral character is the number of abdominal and caudal vertebrae (Table 1, no. 12). In the three brotulids skeletonized counts are: *Brotula*, 15 abdominal + 46 caudal; *Microbrotula*, 12 + 40; *Dinematichthys*, 12 + 34; in *Otophidium*, 16 + 53; in *Snyderidia*, 15 + 58. Emery (1880: 26) gives 125–144 vertebrae for *"Fierasfer acus,"* of which 17 or 18 are abdominal. Arnold (1956) uses the number of trunk vertebrae as one basis for dividing the carapids into three sections, one group having 17–20, another 27 or 28, and a third 30 or 31.

Internal soft anatomy: The air bladder of *Snyderidia* is apparently simple and extends from below the second to below the twelfth vertebra. According to Gilbert (1905: 654) *Snyderidia* has two pyloric caeca.

External characters: Only a few of the external features of *Snyderidia* need be noted. First, the species resembles the carapids in the presence of a long tail that tapers gradually to nothing. Second, though the pectoral of the lava flow specimen of *Snyderidia* has been rather badly frayed, it is possible to count 27 rays on one side. This high count seems to place *Snyderidia* with the brotulids and ophidiids rather than with the carapids (Smith, 1955: 546). Finally, there are no scales whatever.

Relationships: On the basis of the foregoing comparison *Snyderidia* would appear well differentiated from the Ophidiidae, Brotulidae, and Carapidae, but is probably closest to the last. Especially notable carapid characteristics in *Snyderidia* are the absence of pelvic fins, the long anal fin, the tapering body, the lack of scales, and perhaps especially the dentition. Indeed, in all these respects and notably in lower jaw struc-

ture *Snyderidia* bears a considerable resemblance to the carapid genus *Echiodon* (Arnold, 1956). Nevertheless, in another whole series of characteristics *Snyderidia* differs from *Echiodon* and apparently all other carapids. This series may be divided between presumably primitive and presumably specialized features. Among the "primitive" characters in *Snyderidia* may be mentioned the wide gill openings; the comparatively low number of vertebrae, both abdominal and caudal; the relatively high pectoral count; the small, backwardly sloping first neural arch; and the protractile upper jaw. In all these traits *Snyderidia* is closer to the brotulids and ophidiids than to the carapids. Among specialized features in *Snyderidia* may be mentioned especially the fusion of the frontals and the separate angular bone. On the whole then *Snyderidia* might be considered a side branch of the primitive stock from which the carapids have arisen. In the absence of known transitional forms between *Snyderidia* and the carapids, *Snyderidia* would appear to merit separation at the family level.

Though the internal features of *Pyramodon* remain mostly unknown, it seems most probable that *Snyderidia* should be included in Smith's family Pyramodontidae. The chief external difference between the two appears to be the retention of pelvic filaments in *Pyramodon*. To include *Snyderidia*, some slight rearrangement of Smith's definition (see above) of the family seems required. Using only those characters known for both *Pyramodon* and *Snyderidia*, the family Pyramodontidae may be redefined as follows: Body naked, tapering to a fine point posteriorly. Anal fin commencing below the pectoral. Pectoral with 27 rays. Gill openings extending well forward on throat. Upper jaw protractile. Large canines on the front of the vomer and at the symphyses of both jaws.

Some discussion of the remaining ophidioid families seems in order. The Carapidae is obviously the most specialized; indeed in habits the Carapidae is among the most specialized of all fish families, for it and the unrelated Pygidiidae comprise the only two fish families known that have developed parasitic members.

The Ophidiidae is externally separable from the other families in the group by the mental pelvics, though certain brotulid genera have the pelvics nearly as far forward. A more important character, if it applies to all ophidiids, is the peculiar first neural arch (Fig. 4*a*) and its connection with the air bladder; unfortunately this feature remains uninvestigated in what Norman (ms., 1957: 500) calls the subfamily Lepophidiinae.

The Brotulidae is a tremendous and heterogeneous family (Gosline, 1953), which Norman has recently divided into four subfamilies (ms., 1957: 484). That its osteological features cannot be characterized on the basis of internal examination of one species has been abundantly shown, while even the approximate limits of variation remain unknown. Suffice it to say that even the known variation in osteological features (Gosline, 1953) is greater than between many families of the great superfamily Percoidae.

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Spiders from Some Pacific Islands, Part IV
The Cook Islands and Niue

B. J. MARPLES[1]

THE COOK ISLANDS are a group of small islands in the region of the central South Pacific bounded by 8°–23° S. and 156°–167° W. They are divisible into two groups, the northern Cooks which are small atolls, and the southern Cooks which, with one exception, are volcanic islands. The southern Cooks are surrounded by coral formations and in some cases have been raised so that the islands have a coral rim up to 300 ft. high. The largest island is Rarotonga, with an area of some 26 sq. mi. and rising to a height of 2,140 ft. The Society Islands, the next group to the east, lie some 600 mi. from Rarotonga.

The island of Niue will be considered together with the Cook Islands. This isolated island does not belong to any group. It lies at 19° 10′ S. and 169° 46′ W., and consists of a flat coral formation raised to a height of some 220 ft. above the sea, with an area of about 100 sq. mi. It is situated some 580 mi. west of Rarotonga, 300 mi. east of Tonga, and 350 mi. southeast of Samoa.

The spider fauna of these islands is not well known. The number of species recorded (Berland, 1934*a*; Marples, 1955*a*, 1957) are as follows: Rarotonga, 13 species; Pukapuka, 8 species; Aitutaki, 5 species; and Niue, 5 species. In the present paper some of these numbers are raised to: Aitutaki, 24 species; Niue, 30 species; while from islands with no previous records there are: Mangaia, 10 species; Rakahanga, 4 species; Manihiki, 3 species; and Penrhyn, 1 species. I am indebted to my wife and to my son Richard for the collections from Niue and Aitutaki, and to Dr. D. D. McCarthy for those from the other islands. The collections were made during expeditions under the auspices of the Medical Research Council of New Zealand.

Niue is situated closer to the Samoa and Tonga groups and should be considered separately. Of the 30 species, 27 are recorded also from Samoa, 15 from the Cook Islands, and 11 from the Society Islands. Samoa is the largest land mass in this region and the one whose spider fauna is best known. Fiji, to the west, has not yet been adequately explored. Of the three species recorded from Niue but not from Samoa, *Nephila prolixa* represents the most easterly extension of the genus in the Pacific. It occurs in Fiji and Tonga and was recorded by Koch (1871) some 90 years ago in Samoa, but it has not been recorded there since. *Drassodes ciusi*, a new record, was previously described from New Caledonia and the Loyalty Islands far to the west. The third species, *Mollicia microphthalma*, has a wide distribution from the New Hebrides, New Caledonia, and Loyalty Islands in the west, and to the Marquesas and Rapa in the east. It is also known from Tonga, the southern Cooks, and the Society and Austral islands, but not from Fiji, Samoa, or the small islands to the north. This southern distribution is unusual in such a widespread species.

Thirty species are recorded from the southern Cooks, and 26 of them occur also in Samoa. Of the 4 which do not, one is *Mollicia microphthalma* already discussed, and 2 have not been recorded elsewhere. The fourth, *Sandalodes calvus*, is interesting, as it occurs to the east in the Society, Marquesas, and Tuamotu islands. Curiously enough, it is said to occur also in Australia. The genus *Sandalodes* has a distribution unlike that of any other group in the Pacific. There are, in addition to *S. calvus*, 8 species in Hawaii and 5 in the Marquesas. Another possible link with the east is an immature salticid from Aitutaki which may be *Laharulla insulana*, recorded from Tahiti, but unfortunately it cannot be identified with certainty. The southern Cooks have 14 species in common with the Society Islands (Berland, 1934*b*) but the remainder of these occur also in islands to the west. It is highly desirable that adequate collecting be carried out in Rarotonga, which,

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TABLE 1

SPECIES OF SPIDERS RECORDED FROM THE COOK ISLANDS AND NIUE, AND THEIR OCCURRENCE IN THE ADJACENT ISLAND GROUPS

SPECIES	TONGA	SAMOA	NIUE	SOUTHERN COOKS	NORTHERN COOKS	TAHITI
Total number of species recorded	49	128	29	30	8	40
ULOBORIDAE						
U. geniculatus	—	×	×	—	—	—
DICTYNIDAE						
S. mumfordi	—	×	—	×	—	—
OONOPIDAE						
G. loricata	×	×	×	—	—	—
I. lanutoo	—	×	×	—	—	—
O. oceanicus	—	×	—	×	—	—
SCYTODIDAE						
S. marmorata	×	×	—	×	—	×
S. striatipes	×	×	×	×	—	×
OCHYROCERATIDAE						
A. minuta	—	×	×	—	—	—
PHOLCIDAE						
P. ancoralis	×	×	×	×	—	×
A. mauriciana	—	×	—	—	×	—
P. globosus	×	×	—	×	×	—
S. elongatus	×	×	—	×	×	—
CLUBIONIDAE						
C. furax	×	×	?	—	—	—
C. alveolata	×	×	×	×	—	—
C. samoensis	—	×	—	×	—	×
GNAPHOSIDAE						
D. ciusi	—	—	×	—	—	—
LYCOSIDAE						
L. tongatabuensis	×	×	—	×	—	×
ZODARIIDAE						
C. verrucosa	—	×	—	×	—	—
SPARASSIDAE						
H. venatoria	×	×	×	×	×	×
SALTICIDAE						
A. whitmei	—	×	×	×	×	×
A. pterygodes	×	×	×	—	—	×
A. satchelli	—	—	—	×	—	—
B. aericeps	×	×	—	×	×	×
C. piscula	—	×	×	—	—	—
F. minuta	—	×	×	×	—	—
T. ensifera	×	×	×	×	×	×
M. bivittata	×	×	—	×	—	×
M. microphthalma	×	—	×	×	—	×
S. calvus	—	—	—	×	—	×
THERIDIIDAE						
C. samoensis	×	×	×	—	—	×
C. unimaculata	×	×	×	—	—	—
P. soloa	—	×	×	—	—	—
T. albostriatum	×	×	×	×	—	—
T. aleipata	×	×	×	×	—	—
M. phyllicola	—	×	×	—	—	—
LINYPHIIDAE						
L. tuasivia	—	×	—	×	—	—
A. armata	—	—	—	×	—	—
TETRAGNATHIDAE						
D. oceanica	—	×	—	×	—	—
D. upoluensis	—	×	×	×	—	—
L. tuberculata	×	×	×	×	—	×
T. panopea	×	×	×	×	—	—
T. macilenta	×	×	×	×	—	—
EPEIRIDAE						
C. moluccensis	×	×	×	—	—	×
E. theisi	×	×	×	×	×	×
N. prolixa	×	?	×	—	—	—

as a high and relatively large island, will yield far more than the 13 species recorded from it and may show some interesting resemblances to the islands to the east.

The northern Cooks are all small coral islands. Only 8 species are recorded; all of these occur also in Samoa and 5 of them occur in the Society Islands. For comparison the Tokelau Islands may be mentioned. These are small coral islands lying west of the northern Cooks and north of Samoa. Thirteen species are recorded from them, all of which occur also in Samoa. Six of the 8 species from the northern Cooks occur also in the Tokelaus.

ULOBORIDAE

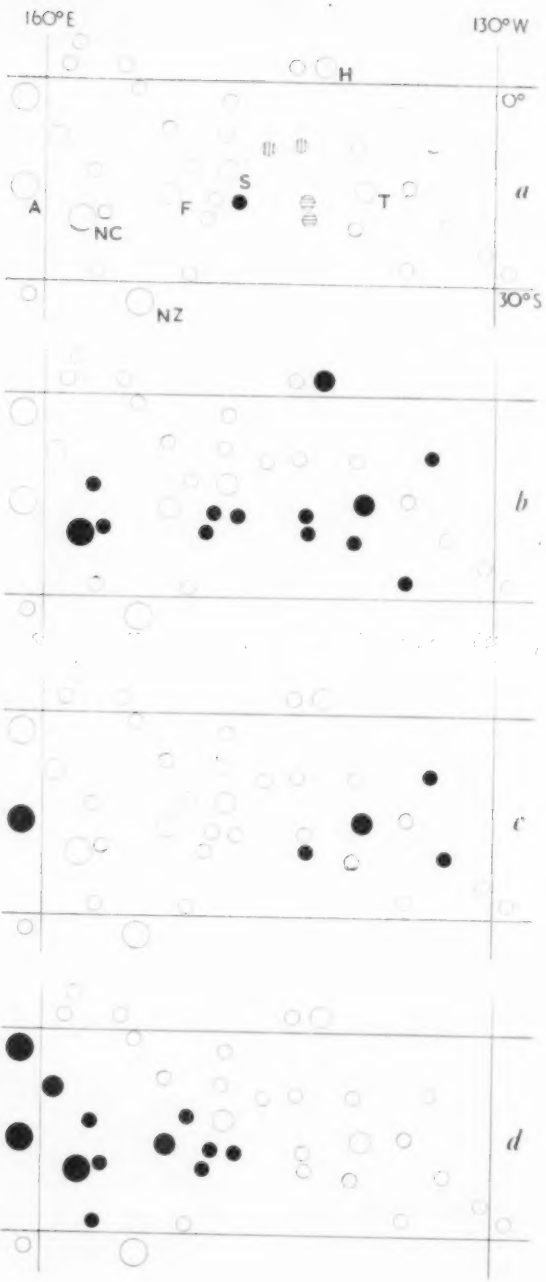
Uloborus geniculatus Olivier

NIUE: 3 Female and 4 imm., 1 male imm. From buildings and a cave, Mutulau.

DICTYNIDAE

Syrorisa mumfordi Berland

AITUTAKI: 6 Females and 12 imm., 2 males. Some collected under bark and others below coral pebbles about 2 in. in diameter on open ground. The webs were spun between the pebbles and the spider was just below. Two cocoons of thin white silk, one contained 36, the other 23 eggs.


160°E
130°W
H
0°
S
A
NC
F
T
a
NZ
30°S
b
c
d

OONOPIDAE

Gamasomorpha loricata L. Koch
NIUE: 3 Females. In dead leaves. Assumed to be this species.

Ischnothyreus lanutoo Marples
NIUE: 1 Female imm. From litter in a plantation.

Oonopinus oceanicus Marples
AITUTAKI: 1 Female imm.

SCYTODIDAE

Scytodes marmorata L. Koch
AITUTAKI: 2 Females. In buildings.

Scytodes striatipes L. Koch
NIUE: 7 Females and 4 imm., 1 male. In house.
AITUTAKI: 5 Females. In house and under logs.

OCHYROCERATIDAE

Apiacera minuta Marples
NIUE: 1 Female imm. Collected under an old fallen cocoanut. There are 5 instead of 6 promarginal teeth on the cheliceral groove.

PHOLCIDAE

Pholcus ancoralis L. Koch
NIUE: 3 Females and 3 imm., 1 male. On buildings and cliffs and in the bush.

Artema mauriciana Walckenaer
RAKAHANGA: 1 Female, 1 male.

Physocyclus globosus Taczanowski
AITUTAKI: 24 Females, 5 males. The details of the palp are not exactly as figured by Petrunkevitch (1929) for a specimen from Porto Rico.
RAKAHANGA: 1 Female.
MANIHIKI: 1 Female and 7 imm., 1 male.

Smeringopus elongatus Vinson
MANGAIA: 1 Female, 1 male.
RAKAHANGA: 1 Female.

CLUBIONIDAE

Chiracanthium furax L. Koch
NIUE: 1 Male imm. Probably this species.
AITUTAKI: 3 imm. Probably a *Chiracanthium* sp.

Clubiona alveolata L. Koch
NIUE: 10 imm. In bush.
AITUTAKI: 2 Females, 1 male, and 1 imm. Under bark and stones.

GNAPHOSIDAE

Drassodes ciusi Berland
NIUE: 1 Female. In open plantation. This species was described by Berland (1924) from a male from New Caledonia. Later (1929) he described a female from the Loyalty Islands which he attributed to the same species. The present specimen appears to correspond to this female.

Poicilochroa rollini Berland
AITUTAKI: 1 imm. Under bark. This may belong to this species but one cannot be certain.

LYCOSIDAE

Lycosa tongatabuensis Strand
AITUTAKI: 5 imm. Possibly this species, the cheliceral teeth agree.

SPARASSIDAE

Heteropoda venatoria (Linn.)
NIUE: 2 Females, 2 males, several imm. Cocoon with 292 eggs.
AITUTAKI: 3 Females, 3 males, several imm. 3 cocoons.
MANGAIA: 1 imm.
MANIHIKI: 2 imm.
PENRHYN: 1 Female, 1 male, 1 imm.

FIG. 1. *a*. A stylised map of the South Pacific. The rectangle is bounded by the equator and 30° S., and by 130° W. and 160° E. The main island groups within the rectangle are indicated by circles in their relative positions, while the land masses without are conveniently assembled round the margin. *A*, Australia; *F*, Fiji; *H*, Hawaii; *NC*, New Caledonia; *NZ*, New Zealand; *S*, Samoa; *T*, Society Islands. The northern Cook Islands are marked with vertical lines, the southern Cook Islands with horizontal lines, and Niue is black.

b. Distribution of *Mollicia microphthalma*.

c. Distribution of *Sandalodes calvus*.

d. Distribution of the genus *Nephila*. Eleven species are included, but the doubtful record from Samoa is not shown.

SALTICIDAE

Athamas whitmei Cambridge
NIUE: 2 Females, 3 males, 3 imm. In house and swept in herbage.
AITUTAKI: 4 Males, 1 imm. Swept.

Bavia aericeps E. Simon
AITUTAKI: 1 Female, 1 imm.

Cytaea piscula L. Koch
NIUE: 2 imm. In bush.

Flacilla minuta Berland
NIUE: 2 Females imm., 1 male. In house.
AITUTAKI: 1 Female. Swept. There is one spine on metatarsus I, instead of none.

Thorellia ensifera (Thorell)
NIUE: 5 Females and 2 imm., 7 males and 3 imm. In house and litter in the bush.
AITUTAKI: 3 Females, 3 males, 5 imm. Swept.
MANGAIA: 2 Females imm.

Menemerus bivittatus Dufour
AITUTAKI: 1 Male. Under bark.
MANGAIA: 1 Female.

Mollicia microphthalma (L. Koch)
NIUE: 2 Females and 1 imm. In bush.
AITUTAKI: 1 Male.

? sp.
AITUTAKI: 1 Female imm. Unfortunately it is not possible to identify this specimen, but it seems to be most like *Lauharulla insulana* Simon, described from Tahiti.

THERIDIIDAE

Conopistha samoensis (Cambridge)
NIUE: 3 Females and 9 imm., 1 male imm. The sides of the abdomen of all these specimens are silver, the ventral side is dark, and there is also a well-marked streak running longitudinally along the whole of the dorsal surface. This is better marked posteriorly to the apex than in Samoan specimens; there is no vertical lateral dark band which some of these have.

Conopistha unimaculata Marples
NIUE: 4 Females and 21 imm., 2 males and 4 imm. Collected in the bush.

Pholcomma soloa (Marples)
NIUE: 1 Female. In bush. This species was described as *Theridion soloa* from a single individual from Samoa. Additions to the description already published (1955*b*) are a row of three minute teeth on the retromargin of the cheliceral groove, and extensions of the broad posterior end of the sternum passing posterior to the last pair of legs. These are present in the type as well.

Theridion albostriatum L. Koch
NIUE: 1 Male. In house.
AITUTAKI: 20 Females and 16 imm., 5 males and 4 imm. In buildings.
MANGAIA: 2 Females, 1 male imm. The common domestic theridiid throughout the Pacific is taken to be this species.

Theridion aleipata Marples
NIUE: 1 Female and 9 eggs in a thin silk cocoon.
AITUTAKI: 2 Females, 1 male imm. Under pebbles on bare ground and swept.

Mysmena phyllicola (Marples)
NIUE: 2 Females, 1 male imm., 1 cocoon with 6 spiderlings. In bush.

LINYPHIIDAE

Linyphia tuasivia Marples
AITUTAKI: 1 Female. Under logs and leaves. The epigynum is slightly different from Samoan specimens, but it seems to belong to this species.

Aitutakia armata gen. et sp. nov.
AITUTAKI: 1 Male. In house. Male. Length 2.28 mm. Pale brown, sternum and mouth parts darker. Abdomen greyer with faint posterior dorsal chevrons.

Carapace: Length, 1.07 mm., breadth, 0.83 mm. Lateral margins convex. Thoracic groove conspicuous and longitudinal.

Eyes: 8, all light. From above, anterior row strongly recurved, posterior row straight. Ratios of the diameters of the eyes and of their distances apart: AM, 91; AL, 117; PM, 97; PL, 110; AM-AM, 53; AM-AL, 41; AM-PM, 76; PM-PM, 76; PM-PL, 80; laterals touching; clypeus, 220. Breadth of eyegroup, 0.39 mm.

Chelicerae: Main part rounded, groove very oblique so that the chelicera tapers towards the base of the fang. Large sharp prolateral distal apophysis, and a row of 5 smaller ones, increasing in size distally, along the prolateral dorsal

margin. Dorsal surface near the base of the fang with a stridulating organ of 7 ridges. Strigil at the proximal end of the tarsal tibia. Five promarginal teeth, the next but one to the ventral end being the largest; 3 somewhat larger retromarginal teeth.

Maxilla: Large and rounded, converging, truncated anteriorly with only a slight anteromedian scopula. Posterolaterally adjacent to coxa I is a rounded dark elevation.

Lip: Small, rounded, broader than long.

Sternum: Length, 0.56 mm., breadth, 0.59 mm. Convex. Hollows for the bases of the maxillae and legs. Extending between the hind legs.

Palp: Tibia drawn out into a sharp dark dorsal process extending distally beside the base of the tarsus, below it a lateral convexity. Three dorsal trichobothria. Details as in figure.

Legs: IV	I	II	III	Palp
2.99	2.86	2.74	2.25	1.27

	FEMUR	PATELLA AND TIBIA	METATARSUS	TARSUS	TOTAL
Palp	0.56	0.41	—	0.39	1.36
I	0.62	1.14	0.78	0.50	3.05
II	0.79	0.97	0.71	0.25	2.73
III	0.71	0.74	0.58	0.38	2.41
IV	0.91	1.06	0.81	0.41	3.19

Tibial Index I 9.0
Tibial Index IV 9.0

Three claws, paired ones with 6 pectinations in a single row, median claw with 1. Spines few and inconspicuous. Tibiae with 2 dorsal spines except IV which has one. One on each patella. The femora have a double row of stout hairs or fine spines.

Trichobothria: 6 in 2 rows on the tibiae and 1 on the metatarsi, including metatarsus IV.

Abdomen: Length, 1.11 mm., breadth, 0.73 mm. Oval, slightly overhanging the waist. Spinnerets posteroventral, 6, the anterior much the largest. Anal tubercle and colulus small. Genital fold conspicuous. Posterior spiracles appear paired and close to the spinnerets.

This species, on the evidence of the converging maxillae, the single spine on tibia IV, and the single trichobothrium on metatarsus IV, would seem to belong to the micryphantid assemblage. It is remarkable for the apophyses on the chelicerae and the swelling on the maxillae which distinguish it from the other species in the region. As its true generic position can only be determined by a specialist on the Linyphiidae, it is provisionally placed in a new genus.

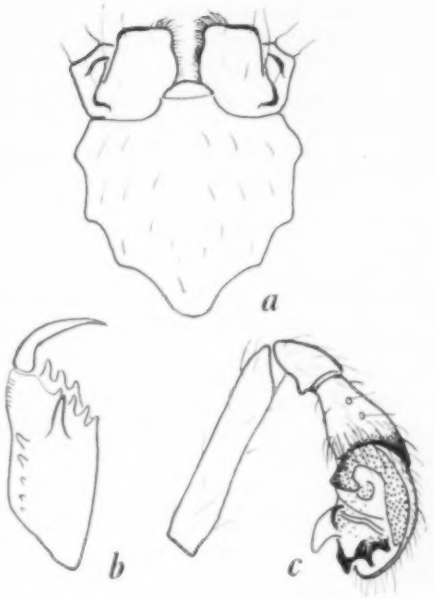


FIG. 2. *Aitutakia armata*, male. *a*, Sternum and maxillae; *b*, prolateral view of left chelicera; *c*, retrolateral view of right palp.

TETRAGNATHIDAE

Dyschiriognatha oceanica Berland
AITUTAKI: 5 Females.

Dyschiriognatha upoluensis Marples
NIUE: 1 Male. Swept in shrubs at night. Smaller than Samoan specimen.
AITUTAKI: 4 Males.

Leucauge tuberculata Keyserling
NIUE: 15 Females, 5 males, 43 imm.
AITUTAKI: 2 Females and 2 imm., 2 males imm.

Tetragnatha panopea L. Koch
NIUE: 1 Female, 1 male.
AITUTAKI: 3 Males.

Tetragnatha macilenta L. Koch
NIUE: 2 Females.
AITUTAKI: 1 Male. The identification of species of *Tetragnatha* is only tentative.

EPEIRIDAE

Epeira theisi Walckenaer
NIUE: 9 Females, 1 male.
AITUTAKI: 10 Females, 5 males.
MANGAIA: 3 Females.
RAKAHANGA: 16 Females.
MANIHIKI: 1 imm. One immature epeirid apparently belonging to another species was collected on Niue.

Nephila prolixa L. Koch
NIUE: 1 Female and many imm., 4 males imm.

Cyrtophora moluccensis Doleschall
NIUE: 6 Females, 5 males and many imm.

SUMMARY

New collections of spiders are described from the Cook Islands and Niue which bring the total numbers recorded to 31 and 29, respectively. These faunas are compared with those of the Society Islands to the east and with those of Tonga and Samoa to the west, and the greater resemblance seems to be with those of the west. One new genus and species is proposed: *Aitutakia armata*, of the Linyphiidae.

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The Arrival of *Aedes (Ochlerotatus) vigilax* (Skuse) in Fiji

G. F. BURNETT[1]

THE SALTMARSH-BREEDING MOSQUITO, *Aedes (Ochlerotatus) vigilax* (Skuse), is a serious pest in parts of Australia, New Guinea, and New Caledonia and is a proved vector of the New Caledonian strain of nonperiodic bancroftial filariasis (Iyengar and Menon, 1956; Iyengar, 1954; Backhouse and Woodhill, 1956). It was reported from Fiji by Lever (1940), but he subsequently decided that this was an error (Lever, 1945). In November, 1957, *A. vigilax* was discovered near Suva and identified with certainty. Some work has been done on this species since its discovery to determine its status as a potential vector of Fijian filariasis and also to find out how it entered the colony. In common with most Pacific territories, Fiji enforces measures designed to limit the importation of pests (especially anopheline mosquitos, which are absent from the group), but *A. vigilax* had obviously evaded these measures.

Acknowledgments: I wish to thank Mr. D. J. Lee, of the University of Sydney, and Mr. P. F. Mattingley, of the British Museum (Natural History), for their very prompt identification of the specimens I sent them. Mr. Lee also supplied most of my information on this mosquito in its natural haunts. I am indebted to Messrs. S. Nelson, G. Martin, J. Buckingham, and M. Natuna, all of the Medical Department, Fiji, for much information. The dissections were largely carried out by Isimeli M. Rakai. My thanks are due the Director of Medical Services, Fiji, for permission to publish this note.

ARRIVAL OF *A. vigilax*

The Fiji group consists of two large islands and numerous smaller ones. The southeast aspects of all the higher islands, including the two large ones, are wet, receiving 100–300 in. of rain per year, and in normal years are not without rain for more than a week or two at a time. The northwest sides of these islands have a distinct rainy season from December to May, the rest of the year being dry. Ports of entry from overseas are virtually confined to the largest island of Viti Levu (see Fig. 1). There are two seaports concerned, the capital, Suva, in the southwest, and Lautoka in the northwest. On the east side of the Suva peninsula is the military and civil flying-boat base of Lauthala Bay. The international airport of Nandi is not far from Lautoka.

On December 20, 1957, mosquito larvae subsequently identified as *A. vigilax* were discovered by the local mosquito control organization in brackish pools at the mouth of a creek within a mile of the flying-boat base at Lauthala Bay. These pools were oiled as soon as the larvae were found, but on January 13, 1958, both adults and larvae were discovered in and near brackish pools about 100 yd. from shore some 1,000 yd. northeast of the original discovery. On succeeding days the infestation was traced, principally as sparse adults, as far as the extensive delta of the Rewa River. During January and February specimens were found at Korotongo, 60 mi. west of Suva, and at Mau, Wainiambia, and Nukui (Fig. 1). At all these places we had made regular surveys at intervals during the previous 9 months and it is most unlikely that *A. vigilax* would have been overlooked unless it was present in very small numbers indeed. At the end of January and beginning of February unusually high tides, backed by strong winds, produced many brackish pools suitable for breeding, and many places in south and east Viti Levu complained of being attacked by swarms of the new mosquito, which was sufficiently distinctive to attract lay comment as

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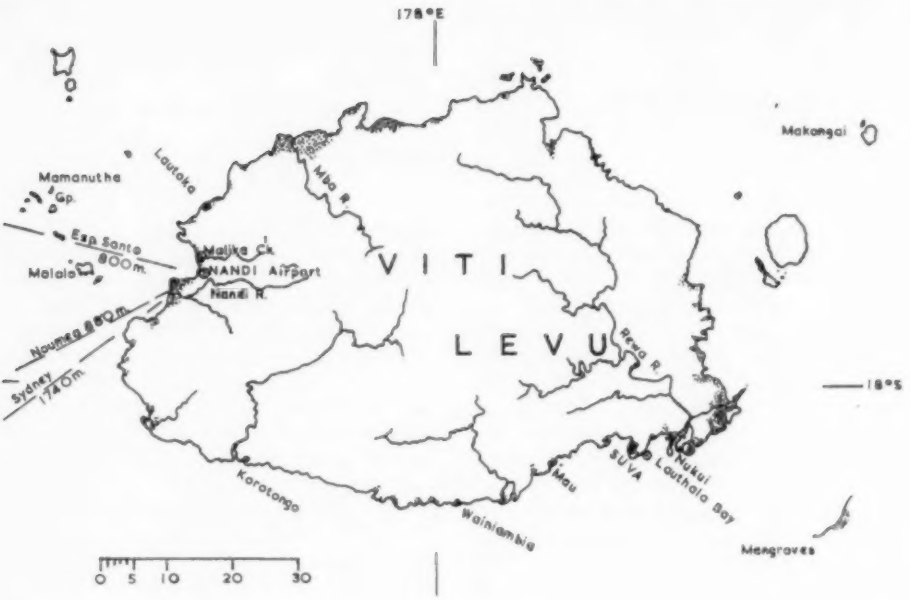

FIG. 1. Viti Levu, Fiji Islands.

something unusual. Suva in particular suffered from prolific breeding in the coastal marshes some 2 mi. distant. In the Rewa delta, breeding was intense in the saline pools left actually within village boundaries by high spring tides. The infestation extended to the dry zone of Viti Levu, being confirmed from Nandi in March, 1958, and near Lautoka in May, while an infestation of plague intensity was found in the Mba delta in June, 1958 (Fig. 1). The inhabitants stated that this had started early in 1958. Thus, shortly after *A. vigilax* was discovered, it became a pest all round the island of Viti Levu, and its initial discovery near the flying-boat base at Lauthala Bay cannot be considered of much significance in deciding its point of introduction. Indeed, although specimens were not obtained near Nandi until March, 1958, there are circumstantial accounts of what was almost certainly *A. vigilax* in the area in October, 1957, and possibly as early as May, 1957. The report originates from the Senior Mosquito Inspector now in charge. He says that when he arrived at Nandi in October, 1957, there were many complaints of daytime biting by mosquitos, which local informants alleged had started in May, 1957. He identified the mosquitos as *Aedes vexans* (Theo.), with which *A. vigilax* is readily confused, especially if the presence of the latter is not suspected, although *A. vexans* rarely bites by day in Fiji. The infestation was traced to an extensive flooded area 1½ mi. to the north of the airfield where the outlet of the Malika Creek (Fig. 1) had been blocked by a broken floodgate. The water was brackish and the Inspector was surprised to find great numbers of what he took to be *A. vexans* larvae in this brackish water. Unfortunately he took no specimens at the time, but in March, 1958, he collected *A. vigilax* larvae in the same place. When I visited the area in June, 1958, the floodgate was repaired and the ground was dry, but it was very similar in character to the places where *A. vigilax* larvae had first been reported near Suva.

Retrospective reports made subsequent to the discovery of *A. vigilax* in Fiji should be carefully scrutinised before acceptance, but there

are reasons for accepting this one. There is no doubt that the species was firmly established in Fiji in 1958, and the soil of the area which I was shown in June of that year was saline. *A. vigilax* is the only species likely to breed here in large numbers, except for the easily distinguishable *Culex sitiens* Wied. or possibly *C. annulirostris* Skuse. The origin of the plague of mosquitos at the airport buildings was not likely to have been within a mile of these buildings because surface water is kept to a minimum within this radius by drainage and unavoidable collections of water are inspected regularly. It is characteristic of *A. vigilax* that it may be a serious pest for up to 5 mi. from its breeding place. There is in fact only one other mosquito in Fiji at all likely to be a pest in daylight in the middle of the large bare expanse of the airfield, and this is *A. aegypti*, which could conceivably breed undetected in water collections near the buildings themselves. It would, however, be recognised by even the least competent mosquito inspector. There is no doubt that there was a mosquito nuisance at Nandi in October, 1957, and it is very likely that this was due to *A. vigilax*, but whether it had really been established since the previous May is more doubtful, because reports of a plague at this time are not supported by any written confirmation. The year 1957 was unusually dry in Fiji and serious breeding of any other species would be most unlikely in this area at this time. In any event the October, 1957, report from Nandi precedes by several months reports of *A. vigilax* from elsewhere.

STATUS OF *A. vigilax* IN EARLY 1959

The plague of *A. vigilax* in the southeast of Viti Levu early in 1958 was brought to a sudden end in April, when over 40 in. of rain fell and there were extensive floods. Dense masses of larvae were seen being washed out to sea by the rising Rewa River. Surprisingly, the insect has not reappeared as a pest in the wet southeastern zone although there have been some unusually high tides which have left brackish pools above normal high water. A few larvae were found in the Rewa delta in January, 1959, but these were washed away by floods. In the dry zone of the island *A. vigilax* has persisted, notably in the Mba delta, in the general vicinity of Lautoka (in small numbers), and near Nandi, where it greatly increased in numbers at the start of the rains in November, 1958 (Fig. 1). It also infests the islands to leeward, e.g., Malolo, where it arrived before May, 1958, when the island was visited in response to a request for help from the islanders. In October, *A. vigilax* was still on Malolo and had reached the Mamanutha Group to the north. It was not found to the windward of Viti Levu until January, 1959, when it was found breeding on Makongai (Fig. 1). It may be assumed that the species is well established and will become a pest again in the wet zone when a suitable combination of conditions arises once more. In Fiji the habits of the insect closely resemble its habits in Australia.

On August 27, 1958, four adult female *A. vigilax* were recovered from an aircraft which had been sprayed on landing at Nandi airport after a flight from Tontouta, New Caledonia. They were fresh and had almost certainly been alive at the time of spraying.

A. vigilax AS A VECTOR OF FIJIAN *Wuchereria bancroftii* AND *Dirofilaria immitis*

A. vigilax from both New Caledonia (Iyengar and Menon, 1956) and Sydney (Backhouse and Woodhill, 1956) have been shown to be highly efficient laboratory vectors of the New Caledonian strain of nonperiodic bancroftial filariasis, and it was feared that it would be equally hospitable to the Fijian strain of the same filaria. The results of various feeding tests are given in Table 1. The mosquitos, aged 2–6 days, were given a single blood meal on the infective subject and were at once isolated in 3″ × 1″ glass tubes containing a strip of filter paper and closed with mosquito gauze. A drop of sugar solution was placed each morning on the strip of filter paper and in the afternoon a drop of distilled water was added. For the last three feeds some *A. pseudoscutellaris* (Theo.), which is an important vector in Fiji, were included as a check. The three insects dissected immediately after the first feed had been killed,

TABLE 1

LABORATORY INFECTION OF *Aedes vigilax* WITH THE FIJIAN STRAIN OF *Wuchereria bancroftii* AND WITH *Dirofilaria immitis*

EXPT. NO.	MICROFILARIAE PER 20 CMM. (MEAN OF 2)	DISSECTED MOSQUITOS											
					MICROFILARIAE		1ST STAGE		2ND STAGE		EARLY THIRD STAGE		MATURE	
		Days after feed	Total	No. with live larvae (all stages)	No. mosquitos	Total no. microfilariae	No. mosquitos	Total no. larvae	No. mosquitos	Total no. larvae	No. mosquitos	Total no. larvae	No. mosquitos	Total no. larvae
123	*W. bancroftii* 5	0	3	0	0									
		7–8	4	0	0									
		9–13	103	2	3	3(2d*)	2	2(1d)						
124	17	2–6	9	0	0									
		9–11	49	5	8	16(d)	1	1	1	2				
125	42	13	20	1	10	14(13d)								
126	241	13–14	35	3	16	102(65d)	3	7(3d)	1	1	1	1	2	2
128	7	2–12	35	2	4	9(6d)	1	2						
		13–18	73	0	4	5(d)	1	1(d)						
Dog 11	*D. immitis* uncountable	8–10	19	1	5	83(d)	5	19(16d)						
		15	10	1							1	6		
		17	5	4									4	11
Simultaneous feedings with *A. pseudoscutellaris*														
125	*W. bancroftii* 42	13	3	3									3	30
126	241	13	22	18	1	4	1	5	3	11			16	106
128	7	1–10	17	10	1	1	6	14	3	3				
		11–13	19	13							7	11	8	29

* d = dead, frequently disintegrating.

but all mosquitos dissected before the 9th day in experiments 123 and 124, and before the 13th day in the other experiments, died naturally and were dissected the same day. In experiment 128 both species suffered the effects of humidities unusually high even for Suva, with consequent high mortality.

The results (Table 1) contrast strongly with those obtained with a New Caledonian donor by Iyengar and Menon (1956) and by Backhouse and Woodhill (1956). This man showed microfilarial counts ranging from 57 to 154 per 20 cmm. of blood, and infected 94 per cent (Iyengar and Menon, 1956) and 95 per cent (Backhouse and Woodhill, 1956) of all *A. vigilax* fed on him. Backhouse and Woodhill also quote a mature infection rate of 98 per cent in those mosquitos dissected from the 12th day onwards. We obtained only 2 mature larvae, in different insects, among 35 mosquitos that fed on a Fijian with a microfilarial count of 241 per cmm. (mature infection rate, 5.7 per cent). Only 3 (8.6 per cent) of this batch showed live filarial larvae, although 82 per cent of *A. pseudoscutellaris* fed at the same time carried live larvae. Batches of *A. vigilax* fed on other donors with microfilarial counts of 5, 17, 42, and seven showed total live infection rates (no stage later than the second) of 1.8 per cent, 8.6 per cent, 5 per cent, and 1.8 per cent, respectively. *A. pseudoscutellaris* fed on the last two showed live infections in 100 per cent and 64 per cent. It appears that *A. vigilax* is a poor vector of the Fijian strain of *W. bancroftii*.

One feed has been done on a dog which was anaesthetised with nembutal (expt. 11). There was heavy mortality of the fed mosquitos, only five surviving 17 days. Of these, four became infective. This high laboratory mortality of *A. vigilax* is most unusual and contrasts with a complete survival in experiment 126 made about the same time. It is almost certainly due to heavy invasion of the mosquitos' excretory systems as a result of feeding on this very heavy

infection. One would expect a lower mortality if they were fed on an animal with fewer microfilariae, but probably a high final infection rate. Few dissections of *A. vigilax* caught wild have been made, but in a series of 30 mosquitos from Raiwai village on the Suva peninsula, one mature larva of *D. immitis* was found.

DISCUSSION

It was most unexpected to find that *A. vigilax* was refractory to the development of Fijian filariae. The insects which reached Fiji are almost certainly derived from Sydney or from New Caledonia because transport from other parts of the range of this species (Iyengar, 1955) is very rare. Since *A. vigilax* from both these places is an exceedingly efficient vector of the New Caledonian strain, it is very probable that difference is not in the strain of mosquito but in the strain of parasite, although both are nonperiodic. This could be confirmed if mosquitos of known provenance were fed on a Fijian donor.

The failure of *A. vigilax* to develop mature Fijian filarial larvae readily was a considerable relief because its habits differ completely from those of our four native vectors (Symes, 1955, 1956). If it were a vector it would be likely to increase the prevalence of filariasis in places where it is at present unimportant, while to control it would require special measures. The arrival of this pest has been beneficial in one way, for it has drawn public attention to the importance of excluding such immigrants and to the need to reconsider the efficacy of the measures in force and of their application in practice.

There is little doubt that this was a new introduction. The only previous report of *A. vigilax* was Lever's (1940), afterwards declared to be an error (Lever, 1945). Since then much work has been done on Fijian mosquitos (Amos, 1947; Symes, 1955, 1956; Laird, 1956) without the detection of *A. vigilax*, and our regular surveys in south and east Viti Levu found none before the first outbreak. Introduction by ship appears less probable than by air because *A. vigilax* would not be at all likely to breed on a ship and is a strong-flying and active insect unlikely to remain on board as an adult for the several days required for its transport. Ships coming direct from any part of its range outside the malarial zone are not subject to fumigation in Fiji, but the waterfronts of the two ports appear inhospitable to the insect. Frequent searches were made along the Suva waterfront but *A. vigilax* larvae were found only once, after the city had been invaded from the other side of the Suva peninsula. Only a few larvae were found and there was no recurrence. At Lautoka, although infestation has persisted on this side of the island, *A. vigilax* has not been found near the harbour.

That the species is capable of being transported by air was demonstrated by its recovery in August, 1958, from an aircraft at Nandi. Of the two air stations, Lauthala Bay normally offers the better facilities for the establishment of a mosquito with the requirements of *A. vigilax*. In addition there is a greater chance that an insect will escape from a flying boat than from a landplane before insecticidal treatment, because it is necessary to open hatches for mooring the former before treatment can be carried out. However, very few aircraft land at Lauthala Bay from places within the known range of *A. vigilax*, whereas Nandi receives many scheduled flights from such places. Opportunities for arrival at Nandi are not only frequent but the first reports of mosquitos that were probably *A. vigilax* came from the airport area during a period when conditions there were unusually suitable for the establishment of this species, suggesting that this was the place of arrival and that on this occasion the usual disinsectisation procedure proved inadequate. The mosquito, once established, presumably spread round the island from the edge of one mangrove swamp to another (see Fig. 1) until unusually favourable conditions of tides and weather permitted simultaneous rapid multiplication to plague proportions over a large area. If this account is correct it emphasizes the importance of the unusual feature, the flooding, which provided a refuge and breeding place on arrival. Introduction of a pest to a new country by man-operated transport depends on a sequence of events—the pest must be present near its potential vehicle, it must be able to enter and remain

within it, survive the journey, survive any treatment designed to destroy it, and escape on arrival and find refuge, food, and a breeding place. It and its offspring must then survive to breed. It is virtually impossible to ensure that no insect can survive any particular one of these stages and efforts should be directed to weakening every link in the chain as much as possible. In the present case it is probable that the unusual facilities offered for breeding were decisive in making the introduction of *A. vigilax* possible. There is no reason why a similar accident should not permit the much more serious establishment of a malaria vector, and all reasonable measures should be taken to prevent it.

SUMMARY

Aedes (*Ochlerotatus*) *vigilax* (Skuse) is a serious pest in Australia, New Caledonia, and elsewhere. In December, 1957, it was found breeding near Suva and within 3 months it had been found round much of the coast of Viti Levu, the largest island of the group, and was established as the worst pest species on the coast whenever conditions favoured its breeding. Its spread is described and its probable mode of introduction, by air, is discussed.

The species is a very efficient host of the New Caledonian strain of nonperiodic bancroftial filariasis but is a poor host of the Fijian strain of this parasite. One experiment indicates that it may be a good vector of the dog filaria *Dirofilaria immitis*.

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A New Hawaiian Engraulid Fish

DONALD W. STRASBURG[1]

THE OCEANIC SKIPJACK or aku (*Katsuwonus pelamis*) is commercially the most important fish in the Hawaiian Islands. This tuna is captured by pole and line, using live bait as chum. Of the several species of small fish employed as bait, the endemic anchovy known as nehu (*Stolephorus purpureus*, family Engraulidae) forms the major skipjack bait resource. Its importance in this respect has made the nehu the subject of several studies, resulting in reports on its food habits (Hiatt, 1951), spawning (Tester, 1951, 1955), oxygen requirements (Pritchard, 1955), meristic variation (Tester and Hiatt, 1952), and taxonomy (Gosline, 1951). Biologically, the nehu is probably the best-known fish in the Hawaiian Islands.

The nehu is a carnivorous anchovy, living and breeding in estuaries and bays. It is captured by seine during the day, and by a combination of seine and electric light at night. The nehu has been regarded as neritic except for two puzzling circumstances: the nehu population in Maalaea Bay, Maui, is periodically augmented by incursions of fish apparently from the open sea, and eggs differing only slightly from those of nehu were once taken in the offshore waters of Oahu (Tester, personal communication).

During the summer of 1958 the research vessel "Charles H. Gilbert" of the U. S. Fish and Wildlife Service encountered several large schools of anchovies 5–30 mi. off Oahu. Samples were presumed to be nehu and were not preserved. Later, conversation with commercial fishermen revealed that, while not regularly occurring, such schools were not rare, and also that the fish differed from nehu in both color and shape. Some fishermen termed these fish "okiiwashi," which is literally translated as "pelagic sardine-like fish," while others referred to them as "roundheads." The latter name was descriptive of the short head which caused the fish to be gilled in seines used for nehu.

Thinking that this offshore anchovy represented either a different species or an ecological variant of nehu, we intensified our efforts to obtain specimens from areas removed from the inshore nehu grounds. Ultimately, two small collections were obtained, one through the interest of Captain Noboru Tsue of the M/V "Buccaneer," the other from biologists of the Territorial Division of Fish and Game (Honolulu). Examination of these specimens proved them to be not only distinct from nehu but also new to science. It is the purpose of this paper to describe and distinguish this new Hawaiian anchovy.

In addition to the collectors, thanks are due also to Drs. Albert L. Tester and William A. Gosline of the University of Hawaii, the former for making available meristic data for nehu, the latter for examining specimens of *Anchoviella mauii*. I am also grateful to Mr. John G. Simpson of the Inter-American Tropical Tuna Commission for data on Central American *Anchoviella*.

METHODS

All meristic data were enumerated from specimens stained with alizarin. Articulated and nonarticulated fin rays were not differentiated, and those rays split to a single base were counted as single rays. All gill rakers, including rudiments, were counted from the first arch on the right side. Distinction between the upper and lower limbs of gill arches was made on the presence of 1–3 rakers with bases embedded in connective tissue between the two portions of the arch. Because most specimens had lost their scales, the number of scale rows was obtained by counting the scale pockets. The only measurement needing description is maxillary length, which was taken as a straight line between the

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FIG. 1. Distinguishing features of Hawaiian engraulid fishes. Compare head length, maxillary length, and pectoral–pelvic interspace. *a. Stolephorus purpureus; b. Stolephorus buccaneeri.*

snout tip and the most posterior portion of the maxillary.

In a recent paper on the scientific name of the nehu, Gosline (1951) mentioned several problems incidental to the use of the term *Stolephorus,* and pointed out the need for a comparison between this genus and the related *Anchoviella.* Although both species of Hawaiian engraulids are referable to *Stolephorus* (Gosline, 1951; Weber and de Beaufort, 1913; Jordan and Seale, 1925, 1926), it is desirable to define this genus as exclusively as possible, for it has not been possible to undertake the needed study of the several engraulid genera. As it is here understood, *Stolephorus* includes those engraulid fishes having separate anal and caudal fins, the dorsal origin anterior to that of the anal, normal upper pectoral rays, bony scutes on the mid-ventral line, maxillaries not extending posterior of the gill opening, and a silvery stripe lengthwise on the body. The genus lacks canine teeth and free spines preceding the dorsal fin (spines are sometimes present in *S. tri* and *S. baganensis* (Hardenberg, 1933*a*)). As far as is known, the species of *Stolephorus* are Indo-Pacific in distribution. The Hawaiian forms can be distinguished from each other by characteristics presented in the following key, Figure 1, and Table 1. Differences between the new species and its congeners are mentioned in the species diagnosis.

KEY TO THE HAWAIIAN ENGRAULIDAE

1. Pectoral and pelvic fins far apart, distance between tip of depressed pectoral fin and pelvic base equal to twice eye diameter; maxillary short, failing to reach anterior edge of preopercle by a distance equal to ½ to ⅔ pupil diameter, maxillary length contained in head length 1.4–1.7 (usually 1.6) times; head short, its length contained 4.1–4.7 (usually 4.1–4.5) times in standard length.....Roundhead.
Stolephorus buccaneeri, new species
2. Pectoral and pelvic fins close together, distance between tip of depressed pectoral and pelvic base equal to ¼ to 1 eye diameter; maxillary long, just reaching anterior edge of preopercle, its length contained in head length 1.0–1.3 (usually 1.3) times; head long, its length contained 3.4–4.0 (usually 3.5–3.8) times in standard length.....Nehu.
Stolephorus purpureus Fowler

Stolephorus buccaneeri, new species
Figs. 1, 2

HOLOTYPE: USNM no. 177742, a male, 53.3 mm. in standard length, taken by seine 200 yd. west of Lehua Island, Niihau, Hawaiian Islands, on September 15, 1958, by Captain Noboru Tsue and crew of M/V "Buccaneer" of Honolulu.

PARATYPES: USNM no. 177743, 19 specimens, males and females, 44.7–58.9 mm. in standard length, taken with holotype; USNM no. 177744, 8 specimens, 40.5–51.5 mm. in standard length, taken from stomach of *Euthynnus yaito* captured 1 mi. off Makua, Oahu, Hawaiian Islands, on September 10, 1958, by Territorial Division of Fish and Game biologists aboard the M/V "Makua" of Honolulu.

DESCRIPTION: Counts made on *S. buccaneeri* are recorded in Table 1, and detailed measurements of the holotype and two paratypes appear in Table 2. Dorsal rays 13 or 14; anal 14–16, the last base usually with 2 rays; pectoral 14–17; pelvic 7; principal caudal rays 9 + 1 + 9; branchiostegal rays 11–13; gill rakers 16 or 17 + 2 or 3 + 23 or 24 (total 41–43); scales in a longitudinal series 41–44, in a transverse series 9(?) or 10(?); scutes on mid-ventral line

TABLE 1
COUNTS MADE ON HAWAIIAN SPECIES OF *Stolephorus*[1]

	DORSAL RAYS		ANAL RAYS		PECTORAL RAYS		PELVIC RAYS		PRINCIPAL CAUDAL RAYS, *baccaneeri*	BRANCHIOSTEGAL RAYS, *baccaneeri*	SCALE ROWS		VENTRAL SCUTES		GILL RAKERS	
	baccaneeri	*purpureus*	*baccaneeri*	*purpureus*	*baccaneeri*	*purpureus*	*baccaneeri*	*purpureus*			*baccaneeri*	*purpureus*	*baccaneeri*	*purpureus*	*baccaneeri*	*purpureus*
0	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—
1	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
2	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—
3	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—
4	—	—	—	—	—	—	—	—	—	—	—	—	14	3	—	—
5	—	—	—	—	—	—	—	—	—	—	—	—	5	1	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
7	—	—	—	—	—	—	19	40	—	—	—	—	1	—	—	—
10	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
11	—	1	—	—	—	—	—	—	—	9	—	—	—	—	—	—
12	—	8	—	—	—	10	—	—	—	7	—	—	—	—	—	—
13	21	126	—	—	—	77	—	—	—	3	—	—	—	—	—	—
14	9	82	6	5	17	175	—	—	—	—	—	—	—	—	—	—
15	—	2	19	55	18	65	—	—	—	—	—	—	—	—	—	—
16	—	—	5	113	7	11	—	—	—	—	—	—	—	—	—	—
17	—	—	—	43	2	2	—	—	—	—	—	—	—	—	—	—
18	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—
19	—	—	—	—	—	—	—	—	22	—	—	—	—	—	—	—
38	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
39	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
40	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
41	—	—	—	—	—	—	—	—	—	—	1	1	—	—	2	2
42	—	—	—	—	—	—	—	—	—	—	3	2	—	—	3	11
43	—	—	—	—	—	—	—	—	—	—	1	5	—	—	5	14
44	—	—	—	—	—	—	—	—	—	—	1	3	—	—	—	35
45	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	41
46	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	36
47	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	25
48	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18
49	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	16
50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7
51	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2

[1] Most data for *purpureus* were supplied by Tester. Both pectoral and pelvic fins were counted, except for the pectorals of some *purpureus*.

2–7 (usually 3–5); vertebrae 43 including urostyle (1 specimen).

Head 215–257, snout 44–59, bony interorbital 48–58, postorbital head length (horizontal) 100–130, maxillary length 141–168, eye diameter 54–79, snout to dorsal origin 473–534, snout to anal origin 672–730, snout to pelvic base 431–504, snout to anterior pectoral base 220–264, longest dorsal ray (2nd or 3rd ray) 119–168, longest pectoral ray 114–145, maximum depth 152–208, least depth of caudal peduncle 75–98, maximum width 112–140 (all measurements as thousandths of the standard length, based on 22 specimens).

Teeth fine, noncaninoid, uniserial on premaxillary, maxillary, and mandible, in small patches and rows on palatines and hyoids, reduced to asperities on vomer; head naked, skin rugose in parietal region; opercle and preopercle without spines; pseudobranchiae well developed; both surfaces of gill rakers finely denticulate; mouth relatively small; posterior tip of maxillary

smoothly rounded dorsally, truncate ventrally, failing to reach anterior margin of preopercle by ½–⅔ pupil diameter; posterior tip of mandible bluntly pointed, just reaching anterior edge of preopercle; ventral profile slightly curved, the ventral mid-line moderately compressed; scutes restricted to region between pectoral and pelvic fins, each with a posteriorly projecting spine and a riblike lateral ramus nearly reaching a pleural rib; caudal forked, the sixth ray from the top and bottom with a fleshy alar flap.

Scales deciduous, cycloid, with 11–13 radiating striae, the anterior 2 or 4 sometimes connecting centrally; anterior scale margin not crenulate; anterior half of scale with fine, parallel, dorsoventral grooves, posterior half with coarse crescentic grooves; an elongate alar scale above pectoral base, none (?) at pelvic base.

Ovarian eggs from a 49.3 mm. maturing female were oval and measured about 0.5 by 0.3 mm. These eggs were whitish and opaque and showed no signs of an oil globule when stained with Sudan IV.

Color in formalin straw or white with a silvery band lengthwise from eye to caudal base, band about ⅔ eye diameter in width at eye and on caudal peduncle, but as wide as eye beneath dorsal fin; tips of snout and mandible blackish, a spray of fine black dots on occipito-parietal region; dorsalmost scale pockets margined in black, particularly on caudal peduncle; dorsal and caudal rays black-spotted, a row of 14 or 15 black spots along anal base.

In life *buccaneeri* is said to be purplish blue, in contrast to *purpureus* which is greenish or brownish.

AFFINITIES: Comparative material of the numerous species of *Stolephorus* was not available, and the relationships of *buccaneeri* were determined almost solely from the literature. All nominal species referable to the genus (as defined above) were considered insofar as possible, but some poorly described forms could not be allocated, nor did descriptions always agree between authors. The authors cited below provided the information by which the species were separated. The order of presentation is not necessarily phylogenetic nor fully dichotomous.

FIG. 2. Holotype of *Stolephorus buccaneeri*, new species (USNM no. 177742) from Lehua Island, Niihau, Hawaiian Islands.

TABLE 2
MEASUREMENTS, EXPRESSED IN THOUSANDTHS OF THE STANDARD LENGTH, MADE ON *Stolephorus buccaneeri*

	HOLOTYPE	PARATYPE	PARATYPE
Standard length (mm.)	53.3	49.8	55.3
Head length	250	215	230
Postorbital length of head	140	124	121
Eye diameter	67	60	54
Interorbital width	51	52	51
Snout length	46	48	49
Maxillary length	164	147	141
Maximum depth of body	187	169	181
Least depth of body	79	76	78
Maximum width of body	137	116	132
Snout to dorsal origin	529	488	528
Snout to anal origin	717	701	691
Snout to pectoral base	258	255	241
Snout to pelvic base	492	452	472
Longest dorsal ray	142	147	134
Longest pectoral ray	105	135	127
Sex	male	female	male

Probably most distantly related to *buccaneeri* are those species of *Stolephorus* having the maxillary extending to the gill opening or nearly to it: *commersoni, waitei, rex, tri, baganensis,* and *insularis* (Jordan and Seale, 1926; Weber and de Beaufort, 1913; Fowler, 1941; Hardenberg, 1933*b*). Another distinctive group includes *evermanni* and *indicus*, both of which have the pectorals reaching or nearly reaching the pelvic bases (Jordan and Seale, 1906, 1926). According to Weber and de Beaufort (1913), the pectoral fins of *indicus* do not reach the pelvic base, but in their material the anal origin was below the middle of the dorsal base, whereas in *buccaneeri* the anal origin is slightly posterior to the rear of the dorsal base. *S. insularum, extensus, holodon, chinensis, nasuta,* and *aestuaria* differ from *buccaneeri* in having 20 or more anal rays (Jordan and Seale, 1926; Fowler, 1941);

and *heterolobus, pseudoheterolobus, zollingeri,* and *purpureus* differ in having the maxillary length contained 1.0–1.4 times in the head length, as opposed to 1.4–1.7 times for *buccaneeri* (Hardenberg, 1933*b;* Fowler, 1941). *S. celebicus* is listed by Hardenberg (1933*a,* 1933*b*) and Fowler (1941) as lacking scutes, and would therefore be excluded from this discussion were it not for the fact that *S. commersoni* occasionally also lacks these structures (Hardenberg, 1933*a*) as does *purpureus* (Table 1). The phylogenetic importance of scutes has been stressed by Jordan and Seale (1925, 1926), but it appears that their variation must be understood before they can be used to effect generic separation.

Some mention must also be made of *Anchoviella mauii.* Although described as new from Maui, Hawaiian Islands (Fowler and Bean, 1923), this species has since been synonymized with *Engraulis australis* by Fowler (1934), who also pointed out that the specimens were mislabeled as to locality.

DISTRIBUTION: *S. buccaneeri* has been collected only from the waters off the northern Hawaiian islands of Oahu and Niihau, and its true distribution is unknown. It also remains to be demonstrated whether schools of offshore anchovies are composed of *buccaneeri* or of *purpureus* or of both. Examination of a collection of anchovies from Maalaea, Maui (where the population is thought to be augmented from offshore stocks), revealed only *purpureus.* Judging from the place of capture of one type series (200 yd. from shore), *buccaneeri* also may be neritic.

REMARKS: It is a pleasure to name this new anchovy *buccaneeri* after the M/V "Buccaneer" of Honolulu. It is suggested that "roundhead" be used as a common name to distinguish this fish from nehu.

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Studies on Pacific Ferns, Part II
Humata and *Ctenopteris*

G. BROWNLIE[1]

THE PRESENT PAPER continues the discussion of problems discovered in nomenclature and distribution of some groups of South Pacific ferns. The first section covers several species of the genus *Humata*, the second, species of *Ctenopteris*, and the third clarifies an apparent error as to the origin of a particular collection of ferns from Aneityum Island in the New Hebrides.

Acknowledgments: I wish to thank Mr. F. Ballard of the Herbarium, Royal Botanic Gardens, Kew, for his assistance with this work, and I acknowledge my indebtedness to the Council of the University of Canterbury for granting the leave during which it was undertaken.

A. SPECIES OF THE GENUS *Humata*

Although Christensen's monograph on the Pteridophyta of Samoa did much to clear up the uncertainty as to the specific limits in the genus *Humata*, it appeared that some aspects required further investigation. The results of this investigation are given in this section, and the present author feels that the position is now clarified for Fiji, Samoa, and Aneityum. Insufficient material was available to be certain of the true situation in New Caledonia, and it appears necessary to await further collections from that island before giving a definite verdict.

Humata sessilifolia (Bl.) Mett.

Davallia aemula Mett. Kuhn Linn. 36: 144, 1869.

Humata aemula (Mett.) Carr. In Seem. Fl. Vit. 335, 1873.

H. aemula was based on a collection by MacGillivray from Aneityum in the New Hebrides and was distinguished by the possession of longer stipes than is usual in *H. sessilifolia*. Very little material from the New Hebrides has been seen, but an examination of Fijian specimens shows the length of stipe to be extremely variable, even on the same plant. This variability is not apparent in Malaysia but occurs also in New Guinea. In the Fijian examples fronds were noted with stipes varying in length from less than 1 cm. to 4 cm., sometimes on the same specimen. In view of this grading of a character previously thought to be distinctive, it appears necessary to reduce *H. aemula* to a synonym of *H. sessilifolia*.

SPECIMENS EXAMINED: New Hebrides—MacGillivray 64 (Kew), Milne 456 (Kew). Fiji—Milne 215 (Kew), 251 (Kew), unnumbered (BM), Horne 805 (Kew), im Thurn 131 (Kew), Thurston unnumbered (Kew), Gibbs 866 (BM), Smith 742 (Kew, BM), 5406 (Kew).

Humata serrata Brack.

Humata serrata Brack. Expl. Exped. 16: 230, 1854; C. Chr. B. P. Bishop Mus. Bull. 177: 38, 1943 (in part).

Davallia botrychioides Brack. var. *multifida* Carr. Christ Engler Bot. Jb. 23: 339, 1897.

Much of the confusion concerning this species has been cleared up by Christensen, but he still gives the distribution as Samoa, Fiji, and New Caledonia. All Fijian specimens, however, have the lamina of the fertile frond more reduced than is the case with the Samoan material, and they invariably lack the horn projecting beyond the sorus. In general, specimens from New Caledonia identified as *H. serrata* are smaller in size than the Samoan ones and approach closer to the local *H. pusilla* in the extreme serrations of the sterile frond. In view of this it appears preferable to restrict the name *H. serrata* to Samoan material.

SPECIMENS EXAMINED: All from Samoa—U. S. Explor. Exped. 6 (Kew), Powell 136

[1] Botany Department, University of Canterbury, Christchurch, New Zealand. Manuscript received May 12, 1959.

(Kew), Whitmee 36 (Kew, BM), 43 (Kew), Christopherson 129 and 177 (BM), McKee 2969 (BM).

Humata botrychioides Brack.

Humata botrychioides Brack. Explor. Exped. 16: 231, 1854.

As pointed out above, this differs from *H. serrata* in the extreme reduction of the lamina of the fertile frond, giving it a more delicate appearance, and in the consistent absence of the horn projecting beyond the sorus. Brackenridge's collection was made in Fiji and the specimens seen from those islands match his plate perfectly.

SPECIMENS EXAMINED: All from Fiji—Milne 330 in part (Kew), Thurston unnumbered (Kew), Graeffe 101 (BM), Smith 453 (BM).

Humata multifida (Bak.) Carr. ex Brownlie.

Humata multifida Carr. ": Seem. Fl. Vit. 335, 1873 (nomen).

Davallia multifida Bak. Syn. Fil. 467, 1874.

Humata botrychioides Brack. var. *multifida* Carr. C. Chr. Ind. Fil. 354, 1906.

Baker originally distinguished this from *H. botrychioides* by the larger, more compound frond, and smaller sori with a horn projecting beyond them. These distinctions, especially the possession of a definite projecting horn, hold good for material from Aneityum. The fertile fronds are similar in appearance to those of *H. botrychioides* with extremely reduced lamina, but the projecting horn is very obvious, being even longer than that seen in *H. serrata.* However, no specimens from islands other than Aneityum have this type of frond and it appears that the species is restricted to that island or possibly to the New Hebrides group.

SPECIMENS EXAMINED: All from Aneityum —MacGillivray 43 (Kew, BM), Milne 294 and 367 (Kew), Milne ex herb. J. Smith unnumbered (BM), Macleay unnumbered (Kew).

B. SPECIES OF THE GENUS *Ctenopteris*

The genus *Ctenopteris* has not previously been closely examined for the South Pacific area, apart from Christensen's clarification of names for the Samoan species. It was quickly apparent that several of the species from different islands, described under different names, are in fact identical. The following section covers the main aspects cleared up in this genus, but further work is required on material from the Society Islands.

Ctenopteris crassifrons (Bak.) Brownlie, comb. nov.

Polypodium crassifrons Bak. Syn. Fil. 325, 1867.

Polypodium stenopteron Bak. J. Bot. 24: 183, 1886.

Polypodium purpurascens Nad. Copel. B. P. Bishop Mus. Bull. 59: 100, 1929 (excluding Society Is.).

Copeland wrongly identified Baker's *P. stenopteron* from Fiji with *P. purpurascens.* In his monograph on the ferns of the Society Islands, however, he states that the latter species has the surface densely beset with minute black hairs, whereas Baker's type at Kew has both surfaces of the frond thickly covered with sizeable reddish-brown hairs. This is also the case in the type specimen of *P. crassifrons,* which in addition has the soral characters identical with those of *P. stenopteron.* Since *P. crassifrons* is the earliest description, the name for both the Fijian and the New Caledonian plants should be *Ctenopteris crassifrons.*

SPECIMENS EXAMINED: All at Kew; Fiji—Thurston unnumbered (Baker's type), Parkes 20820, Smith 4986 and 5178, im Thurn F. 26; New Caledonia—Deplanche no. 2 (Baker's type), Herb. Macleay unnumbered.

Ctenopteris seemanni (J. Sm.) Brownlie, comb. nov.

Polypodium contiguum Brack. Explor. Exped. 16: 6, pl. 2, 1854 (not of others).

Cryptosorus seemanni J. Sm. Bonplandia 9: 262, 1861.

Polypodium lepidum Brause Notizbl. Bot. Gart. Berl.-Dahlem 8: 159, 1922; C. Chr. B. P. Bishop Mus. Bull. 177: 113, 1943.

Polypodium seemanni (J. Sm.) Copel. B. P. Bishop Mus. Bull. 93: 69, 1932.

Christensen has already pointed out that the Fijian *P. seemanni* and the Samoan *P. lepidum* may not be distinct from one another. In fact, the lengthened fertile segments which are char-

acteristic of *P. lepidum* are shown also in some of the Fijian specimens examined, notably Horne 728 and Seemann 821. Although the variability is greater in material from Fiji, I have no doubt that there is only one good species represented. The range of the species is extended to Aneityum by two collections from that island, previously identified as *Polypodium blechnoides*, which have the characteristic elongated fertile segments of the Samoan form.

SPECIMENS EXAMINED: All at Kew; Fiji—Brackenridge 7, Seemann 821, Horne 728, Smith 1898 and 6436; Samoa—Whitmee 128, Powell unnumbered; Aneityum—Milne 317, Kajewski 886.

Ctenopteris hornei (Bak.) Brownlie, comb. nov.

Polypodium hornei Bak. J. Bot. 17: 298, 1879.

This species appears to be closely related to the preceding one, and in fact may be only a form of it, but as I have seen no material other than Baker's type specimen, it is better retained in the meantime as distinct. It differs in the rounder sori, distinctly pubescent stipe, and the more plentiful pubescence on the rachis. The stipe is also markedly shorter.

SPECIMEN EXAMINED: Fiji—Horne unnumbered (Kew, Baker's type).

C. ON A COLLECTION FROM ANEITYUM ISLAND

During the course of the above investigations the present author had reason to refer to Kuhn's two papers "Reliquiae Mettenianae" in which several type specimens from Aneityum were ascribed to Cuming during the years 1858–60. It was realised that these could not possibly have been collected by Cuming at the time indicated inasmuch as he had been in the Pacific in the 1830's. Specimens with the same collection numbers as given by Kuhn were found at Kew and at the British Museum (Natural History), those at Kew having no collector's name but those at the British Museum having MacGillivray's name added later. Through the kindness of the late Mr. A. H. G. Alston, photographs of the specimens of *Humata aemula* from the herbaria of Mettenius and Kuhn were compared with the sheets located in England. The example from Mettenius' herbarium had a printed label with the number (64) and "Aneitum, New Hebrides, Feb. 1860" with "Mountain woods on trees" added in writing in the same manner as on the English sheets. Other labels had been added by Mettenius. From the Kuhn herbarium the one sheet had written labels only, so it appears that those specimens may have been separated from an original sheet. Although the numbers were the same in every case, the dates varied on the four sheets from December, 1858, to February, 1860, making it appear that the numbers were given by the collector to everything that appeared to be the same species. Comparison of other sheets at Kew and the British Museum showed the same discrepancy in dates.

An account of MacGillivray by Maiden (1909) showed that he was resident in Sydney at the time and was known to make trips to the Pacific islands, so it appeared possible that he was responsible for the collections. In fact, in the "Synopsis Filicum" Baker (1874) ascribed the specimens to MacGillivray without indicating the reason for his disagreement with Kuhn. The final solution came with a comparison of the writing on the original labels (the words "Mountain woods on trees" appearing on most of them) with correspondence from MacGillivray in the Hooker letters at Kew. This proved conclusively that they were his collections and that Kuhn's ascribing them to Cuming in his descriptive papers was an error.

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Observations on the Toxic Sea Anemone, *Rhodactis howesii* (Coelenterata)

EDGAR J. MARTIN[1]

THE SEA ANEMONE *Rhodactis howesii* W. S. Kent 1893 belongs to the phylum Coelenterata, order Corallimorpharia, family Actinodiscidae. This animal occurs on reefs in tropical areas of the Pacific Ocean (Cutress, 1957). The present study was done with specimens from the reefs of the Samoa Islands. American Samoans call *R. howesii* "matamalu" and attribute a form of fatal poisoning to either suicidal or inadvertent ingestion of the raw sea anemone. Such cases have repeatedly been mentioned by local medical authorities. However, cooking in water destroys the poison and cooked "matamalu" is commonly eaten by the natives.

While on a tour of duty at the Hospital of American Samoa, the author observed three cases of this poisoning. Shortly after the alleged ingestion of the sea anemone the patients went into stupor which lasted from 8 to 36 hours, depending on the case. During this period, knee jerk and pupillary light reflexes were absent but blood pressure and pulse rate were normal. All patients finally went into prolonged shock. They died with pulmonary edema. The clinical history and course of the poisonings recalled paralytic shellfish poisoning (Meyer, 1928). The phase of stupor suggested that the poison had either a curare-like action or affected primarily the central nervous system. The long duration of this phase suggested that the poison was different from known paralytic marine poisons and that it would be worthwhile to investigate it.

The paucity of research facilities on the islands restricted us to a study of general properties of the poison. We hoped that information so obtained would be adequate for both comparing this poison with other "marine poisons" and studying the conditions of preservation under which the highly perishable sea anemone could be shipped overseas to research laboratories with its poison intact. A bio-assay had to be worked out, using what was available. Various snails and fishes and the toad *Bufo marinus* L. (Oliver, 1953)[2] were tried. All showed some response to the poison, but that of *B. marinus* was the most suitable for a bio-assay. When the toads were injected with homogenates of sea anemone their survival time showed a definite relation to the injected dose.

METHODS

The toads were captured the evening before the experiments. From the time of their capture till the end of the observations they were given no food and were kept moist in darkness at an environmental temperature of 25–30° C. Fourteen to 16 hours after capture the toads were weighed and injected intraperitoneally with homogenates, five toads being used at each dose level. After injection each toad was turned over on its back at intervals, and its alertness and ability to return to normal posture were noted. The toads showed no change in behavior and reactions for several hours after injection. Then, suddenly, their responsiveness to change in posture and their mean frequency of respiration decreased, and within the following half-hour to 2 hours they died. In most of the toads the parotoid glands turned white immediately before or as death occurred.

For the bio-assay whole sea anemones were homogenized in an Osterizer with 4 times their volume of distilled water and then were further diluted with 0.9 per cent NaCl solution for easier handling. In assays with "fresh" sea anemones the time elapsed from the harvesting of a batch on the reef until the last injection of its homogenate into the toads was 4–6 hours.

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[2] *Bufo marinus* was introduced on Tutuila, American Samoa, by D. H. Butchart in 1951 (Butchart, 1957), and presently abounds on that island.

During this period the environmental temperature was 25–30° C. The tolerance of toad peritoneal cavity to distension by the volume of injected homogenate was estimated at about 8 ml. of homogenate for 100 g. of toad. This set the upper limit of the doses at 8 μl. of sea anemone per gram of toad.

Survival time was measured as the elapsed time, in hours, from the moment of injection until death. In recording this, actual survival time was rounded out from the half-hour mark to the nearest full hour. Observations were not extended beyond 48 hours after injection. The lowest dose which caused death in a high proportion of toads within this period of time was found to be 1 μl/g.

EXPERIMENTS AND RESULTS

1. Basic experiments showed the following results: (1) Toads of different weights, ranging from 30 to 100 g., were equally susceptible to the poison. (2) Various amounts of diluent added to the homogenate did not affect the dose effect curve. (3) Toads did not die after injection of any of the following: (a) a clear fluid which spurts from the sea anemone upon touch and slight pressure; (b) a jelly-like substance which the sea anemone secretes upon exposure to air; (c) sea water. (4) Homogenates which were dialyzed with running chlorinated rain water of pH 6 for 12 hours at 22° C. yielded the same dose effect curves as the fresh material of the batches from which they had been taken.[3] It was noticed that the pungent smell of the original material disappeared during the dialysis. (5) Homogenates which had been heated in a boiling water bath for 15 minutes caused no mortality among injected toads.

2. For evaluation of "fresh" homogenates, twelve batches of *R. howesii*, harvested on nine irregularly spaced days, were assayed. Figure 1 summarizes the dose effect curves of these assays.

A total of 225 toads was injected with doses of 2, 4, and 8 μl/g. Eight of them, with the three doses distributed at random, survived for more than 48 hours. A total of 75 toads was injected with 1 μl/g, and 20 of these survived for more than 48 hours. Only the data from toads which died within less than 48 hours were used for Figure 1.

The data of Figure 1 are derived from dose effect curves from batches which were harvested during all seasons of the year over a period of 14 months. Included were batches from a yellow-brown and a dark blue variety of *R. howesii*, both of which occur on the reefs of American Samoa; from each of two different colonies of sea anemones which grew a mile apart from each other; and from a colony which had been transplanted from its normal habitat on the reef to the shore line of the lagoon and kept there for 6 months. The narrow range of variability of the dose effect curves indicates that the poison content of *R. howesii* is not subject to seasonal variations and that it is the same in varieties of two different colors, in colonies of different locations of the area, and in colonies transplanted under the experimental conditions.

3. Evaluation of effects of preserving procedures: Two portions of a given batch of sea anemone were assayed to establish dose effect curves of the fresh material (controls). Two other portions of the same batch were preserved under a given condition and assayed after 8–14 days of preservation (experimental series). Dose effect curves of the experimental series were compared with those of the controls. The significance of differences of mean survival time at any one dose (Burn *et al.*, 1950) was estimated by the *t* test. The 2 per cent level of *P* was taken as the limit of significance.

4. Experiments with preserved homogenates: (1) Sea anemones were mixed with their weight of sodium chloride. A 5 per cent sodium carbonate solution was added until the mixture showed a pH of about 8. The mixture was kept at 25–30° C. for 8 days, after which it was dialyzed and assayed. It was found that the survival times, as compared with the controls, were significantly prolonged at doses of 2–8 μl/g and that there was no mortality at the dose of 1 μl/g. (2) The same experiment was done with a 2 per cent HCl solution added until the mixture showed a pH of about 5. It gave the same results as the experiment at alkaline

[3] pH was estimated with nitrazine paper.

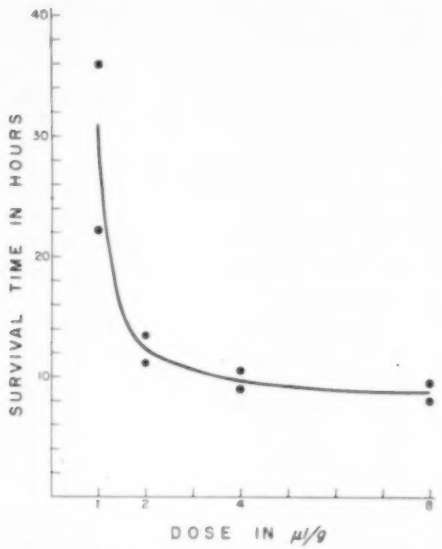

FIG. 1. Relation of dose to survival time of *Bufo marinus* injected with "fresh" *Rhodactis howesii*. At each dose level, two dots show the highest and lowest mean obtained in 15 assays. In each assay, five toads were used at each dose level.

reaction. (3) Sea anemones were mixed with 3 times their volume of ethyl alcohol and kept at 25–30° C. for 14 days, after which the mixture was dialyzed and assayed. It was found that mean survival times at doses of 4 and 8 μl/g were the same as in the controls, but at doses of 1 and 2 μl/g they were significantly prolonged. (4) Sea anemones, without addition of any substance, were kept at 3° C. for 14 days, after which they were assayed. The dose effect curves were found to be the same as in the controls.

Among the preserving procedures tested, refrigeration proved to be the only one suitable for our purpose.

DISCUSSION

The following discussion is based on the assumption that the poison which caused death of the toads is the same as that which caused death of the humans. Its nature is unknown.

According to one classification, "marine poisons" may be of infectious, allergic, or paralytic type (Muller, 1935). Neither the symptoms of our patients nor prevailing environmental conditions suggested banal infectious agents as the cause of the poisonings. Furthermore, persons who repeatedly manipulated both the sea anemone on the reefs and its homogenates in the laboratory with their bare fingers did not experience the sensation of being stung nor did they manifest any skin lesions at later dates. Thus it is uncertain whether the discharge of the nematocysts of *R. howesii* is capable of injuring the human tegument and whether the poison is contained in the nematocysts or in the tissues (Phillips, 1956). But it is certain that for human skin the allergenic potentialities of *R. howesii* are negligible as compared with those of some other sea anemones and of squids (Sonderhoff, 1936; Halstead, 1957).

The poison of *R. howesii* seems to be of the paralytic type and, as is the case with the paralytic poisons of mussels and clams, it can be assumed that it is composed of more than one toxic principle (Sommer and Meyer, 1937). However, it differs from these in several respects. In poisonings with *R. howesii* the stage of stupor is long and cannot escape any observer, while mussel and clam poisonings seem more rapidly fatal, and a stage of stupor—if it exists—seems not to be impressive (Meyer, 1928; Medcof *et al.*, 1947; Tennant *et al.*, 1955). The degree of toxicity of mussels and clams changes with the seasonal variations of the density of poisonous dinoflagellates in the plankton (Sommer *et al.*, 1937), but *R. howesii* showed no seasonal change in toxicity.

Some toxic marine invertebrates have been found to derive their poison from one or the other of the following: their own tissue metabolism (Erspamer and Benati, 1953), the metabolism of a symbiont which lives in the tissue of the invertebrate (Zahl and McLaughlin, 1957), and the ingestion of poisonous plankton (McFarren *et al.*, 1957). By analogy it can be speculated that one or the other of these modalities may apply to *R. howesii*.

Various sea anemones have been found to contain homologues of amines and ammonium bases of varying degrees of toxicity (Ackermann *et al.*, 1923; Ackermann and Janka, 1953; Welsh, 1955) and high proportions of fatty acids and

sterols (Bergmann *et al.*, 1956); and for the sea anemone *Metridium senile* it was suggested that a mucoprotein participates in the poison of its nematocysts (Phillips, 1956). Substances of these classes probably occur in *R. howesii*, but it cannot be said whether they contribute to its toxicity. Since *R. howesii* loses its toxicity when heated, but not when dialyzed, it is suggested that proteins may play an important role in the composition of its poison.

From the clinical symptoms observed in our patients we could not determine whether the poison had a curare-like action or affected primarily the central nervous system. The symptoms of poisoning in *B. marinus* could not be interpreted, since we had no basis of comparing them with the effects of pure drugs on the toad.

The present preliminary study was terminated when we had established that refrigeration was suitable to preserve the poison of *R. howesii* during shipment.

CONCLUSIONS

1. *R. howesii* contains a paralytic poison which differs from other known "marine poisons" of this category. The duration of the phase of stupor observed in three cases of poisoning in humans was comparatively very long. The human skin is not affected by contact with *R. howesii*.

2. The poison does not dialyze at pH 6 and is inactivated within 15 minutes in the boiling water bath. There is no detectable loss in toxicity when the raw sea anemone is kept at 3° C. for 2 weeks.

3. The poison content of *R. howesii* does not depend on the color of the sea anemones and shows no seasonal variations. The toad *B. marinus* L. is suitable for bio-assaying *R. howesii*.

ACKNOWLEDGMENTS

The author is indebted to Mr. C. E. Cutress, Smithsonian Institution, Washington, D. C., for identifying the sea anemone from specimens in formalin and for his valuable comments; and to Drs. K. F. Meyer and L. Farber, the George Williams Hooper Foundation, University of California Medical Center, San Francisco, for their encouragement and for testing a batch of *R. howesii* in their laboratory.

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Corrections and Additions to the Flora of the Hall Islands and to the Flora of Ponape

BENJAMIN C. STONE[1]

SINCE THE PUBLICATION of a check list of the plants collected in Namonuito and the Hall Islands (Caroline Islands) (Stone, 1959: 88–104), certain corrections and additions have come to the author's attention. Owing to an oversight, the collection of plants made on Nomwin Atoll by F. R. Fosberg was not mentioned. Fosberg visited Nomwin on May 29 and 30, 1946, and collected 52 specimens, including certain mosses and fungi. A brief report was issued as carbon copies, but no critical determinations were included in it. Most of the specimens are now widely scattered to various institutions and so were unavailable to the present author. However, only a few of these specimens have not been previously mentioned. Since the collections are currently being examined for the "Catalog of the Micronesian Flora," they will not be cited here in detail.

HALL ISLANDS

DIOSCOREACEAE: *Dioscorea* sp. The yam, probably *D. bulbifera*, was collected on Nomwin (Fosberg no. 24589).

PIPERACEAE: *Piper fragile* Bentham. Hook. J. Bot. 2: 234, 1843. This was first included (Stone, 1959: 100) as a tentative determination. It has now been substantiated by T. G. Yuncker (1959: 92) on the basis of Fosberg's no. 24580 from Nomwin. This species and *P. ponapense* C.DC. are also to be found on Namonuito.

COMBRETACEAE: *Terminalia Catappa* L. Observed by Fosberg on Nomwin.

The following corrections have been necessitated by further study or in agreement with recent research:

DAVALLIACEAE: *Nephrolepis hirsutula* (Forst. f.) Presl. Tent. 79, 1836. At the suggestion of Dr. Fosberg, the plant previously cited as *N. biserrata* (Sw.) Schott was re-examined, resulting in this change. Even this, however, is perhaps still doubtful, and the distinctions between these two species and *N. exaltata* do not always seem clearly applicable to certain Micronesian specimens of this fern.

LEGUMINOSAE: *Canavalia microcarpa* (DC.) Piper is listed by Kanehira (1935: 328), Glassman (1953: 300), Anderson (1951: i), and Fosberg (1955: 11) from various localities in Micronesia. Fosberg's specimen from Nomwin (no. 24586) tentatively has been called *C. microcarpa*. This may represent a second species of *Canavalia* in the Hall Islands, but the species of Micronesia require a broad and careful study to clarify their status and names. Kanehira (l.c.) lists four species, one of which (*C. megalantha* Merr.) is presumably restricted to Guam. *Canavalia ensiformis* (L.) DC. was reported from Guam, Yap, and Jaluit. *C. lineata* (Thunb.) DC. was reported from Guam, and later from Truk (Hosokawa, 1937: 191). St. John (1951: 282) has recorded *C. sericea* Gray (the type from Fiji) from the Marshall Islands. If the Guam endemic is truly so, there are thus five taxa to be considered, including *C. maritima* (Aublet) Thouars, which is recorded from Ponape by Glassman (1952: 74). That the genus includes a number of Pacific species is not to be doubted, but until a revision of the group is initiated, some confusion must exist about the occurrence and distribution of the Micronesian species.

EUPHORBIACEAE: *Phyllanthus amarus* Schum. & Thonn. This name should replace *P. niruri* L. (cf. Stone 1959: 102). G. L. Webster (1956) has shown that the Pacific plants which generally have been called *P. niruri* belong actually to *P. amarus*, and that the former is an American species apparently not occurring in the Pacific. The plants from Ponape which have been called *P. niruri* probably also should be *P. amarus*.

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GOODENIACEAE: *Scaevola sericea* Vahl should replace *S. frutescens.*

VERBENACEAE: *Callicarpa candicans* (Burm.f.) Hochr. should replace *C. cana.*

PONAPE

During the early part of 1957 the writer had the opportunity to botanize in Ponape. The following records are intended as supplementary to Glassman's excellent list of the flora (1952). Several hundred specimens were collected, but only those of particular interest because of rarity or which are new records will be cited here. (S. indicates the author's collection.)

HYMENOPHYLLACEAE: *Cephalomanes boryanum* (Kunze) V.d.B. (Ponape, Mt. Tolen-kiepw trail, elev. 1,000 ft., growing on wet rocks, fronds blackish-green in reflected light, yellow-green and translucent in transmitted light, common, 23 March 1957, S. 1730.)

Trichomanes intermedium v.d.B. (Same locality and date, S. 1739.) These two determinations by Dr. K. U. Kramer. A new record for Ponape.

ASPLENIACEAE: *Loxoscaphe* sp. (vel aff. L. *foeniculaceum* (Hooker) Moore, of Fiji.) (Same locality and date, at a higher elevation of 1,700 ft., epiphytic, the pinnae stiff, S. 1743.) Not previously listed for Ponape.

Prosaptia alata (Bl.) Christ. (Same locality and date, S. 1737.) Known previously from Ponape and Kusaie, but sparsely represented from Ponape. Det. K. U. Kramer.

Weatherbya accedens (Bl.) Copel. (Mt. Tolen-kiepw trail, elev. 1,700 ft., 24 March 1957, S. 1745.) A small epiphytic fern (described from Java) previously collected in Ponape by Kanehira, Takamatsu, and Glassman.

OXALIDACEAE: *Averrhoa Carambola* L. The carambola is planted around the Protestant Church in Colonia.

NYCTAGINACEAE: *Mirabilis Jalapa* L. This ornamental herb, so frequent in atoll villages, is also to be seen in and around Colonia.

MELASTOMACEAE: *Astronidium ponapense* (Kanehira) Markgr. (Mt. Tolen-kiepw, 1,700 ft. elev., 24 March 1957, S. 1749.) This, like *Melastoma,* is called by the Ponapeans "kisetikumai."

LEGUMINOSAE: *Pongamia pinnata* (L.) Merr. Probably introduced by the German or Japanese administrations, this tree occurs at the Agriculture Station and elsewhere. It may be considered an escape. Another tree which may be a *Dalbergia* occurs at Madolenimw. (*P. pinnata,* Agric. Sta., 25 March 1957, S. 1758.)

Mucuna ponapeana Hosokawa. A vine endemic to Ponape, this plant is of interest because of its large handsome leaves and scarlet, fuzzy, usually one-seeded pods. It deserves to be cultivated as an ornamental. (Colonia, 500 ft. alt., 24 March 1957, S. 1751.)

MYRSINACEAE: *Maesa carolinensis* Mez. This species is called "kahbolus." (Mt. Nanalaut, elev. 2,000 ft., 3 June 1957, S. 2004.)

RUBIACEAE: *Ixora coccinea* L. A yellow-flowered low ornamental shrub planted around the Agriculture Station grounds. (Agric. Sta., 25 March 1957, S. 1752.)

GOODENIACEAE: Here, as in the Hall Islands, the species commonly cited as *S. frutescens* must now be called *S. sericea* Vahl, as *S. frutescens* is apparently restricted to the Caribbean area.

VERBENACEAE: *Gmelina asiatica* L. Planted, and tending to escape, at the Agriculture Station (S. 1788).

PANDANACEAE: *Pandanus patina* Martelli. (Summit of Mt. Nanalaut, 2,500 ft. elev., 5 June 1957, S. 2033.) This beautiful species is one of the most perplexing of the Ponapean flora if the question of origin is raised. Its disposition in the genus sectionally is open to doubt. Martelli placed it in Section *Lophostigma,* and Kanehira retained this placement. Yet the plant displays characters which make such a disposition seem precarious. Along with *P. Kanehirae* Martelli and *P. syozoi* Kanehira of Palau, this is one of the most interesting species of the Micronesian flora. *P. patina* forms localized pure stands on several summit areas in Ponape. Its magenta, one-carpellate drupes contain a large edible seed, comparable in flavor to coconut, and sometimes important to hunters or travelers

in Ponape. Seeds of this Ponapean endemic have been germinated in Honolulu, and it is hoped that one of these at least will be male, for the male inflorescence of this species has never been collected.

Glassman (1952: 111-112) thinks that some of the coastal species of *Pandanus* may be forms of *P. dubius* Spr., in reference to the numerous species described by Martelli, Kanehira, and Hosokawa. Probably the only "form" of *P. dubius* which might be found in Ponape would be its close relative, *P. tetrodon* (Gaud.) Balf. f., which has recently been collected in Kapingamarangi Atoll (S. 1940, male; S. 1941, female). *P. dubius*, though frequent elsewhere in Micronesia (Palau, Guam, Saipan, Truk, etc.) has apparently not been found in Ponape, though it occurs on Nukuoro Atoll to the south (S. 1952). The coastal species found in Ponape are manifestly of Section *Pandanus*, while *P. dubius* and *P. tetrodon* are of Section *Hombronia*. *P. tetrodon* is not found in Ponape, either. It is no doubt true, as Glassman and Fosberg state, that the great majority of the "species" are horticultural forms; but that they are horticultural forms of *P. tectorius* has not yet been shown. Current research on this problem may eventually furnish a solution.

CYPERACEAE: *Scirpodendron ghaeri* (Gaertn.) Merr. This enormous sedge occurs in standing water or mud near streams. It is stemless with erect (but eventually drooping) scabrous leaves up to 14 ft. long, about 2 in. wide, with serrate margins of small crowded teeth 0.5 mm. long, and less than 1 mm. apart. The inflorescence is a racemose spike of bracteate heads, on a sharply triangular stalk 60×1.8 cm., subtended by a leaflike bract about 8 ft. long. The nutlets are 1.3×1 cm., ellipsoid and strongly ribbed, containing a single globose gray-black seed 0.7 cm. long. (Net District, banks of Tawensokola River, 17 April 1957, S. 1817.)

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Hawaiian Helminths, Part III
New Opecoelid Trematodes[1]

W. E. MARTIN[2]

THE OPECOELID TREMATODES described in this paper were collected from Hawaiian fishes by the author during a sabbatical leave spent mainly at the Hawaii Marine Laboratory of the University of Hawaii. A recent review of the family Opecoelidae by Skrjabin (1958) includes, among others, keys to the genera *Opecoelus* and *Coitocaecum* which contain four of the five species described in the present paper. The fifth species is assigned to the genus *Pseudopecoeloides*. A sixth species in this family, *Dactylostomum caballeroi*, collected in Hawaii is described elsewhere (Martin, in press).

The specimens described here were fixed in Heidenhains' solution, stained with either Mayer's paracarmine or Celestin Blue B, and mounted in H–S–R mounting medium.

All measurements are expressed in millimeters.

EXPLANATION OF FIGURES

All drawings were made with the aid of a camera lucida. Abbreviations used: *A*, acetabulum; *C*, cecum; *Ci*, cirrus; *CS*, cirrus sac; *E*, excretory vesicle; *G*, genital pore; *M*, metraterm; *O*, ovary; *P*, prostate; *S*, seminal vesicle; *T*, testis; *V*, vitellaria.

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The opinions or assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the naval service at large.

I wish to thank Drs. A. H. Banner, R. W. Hiatt, and L. D. Tuthill of the Marine Laboratory and the Department of Zoology and Entomology, University of Hawaii, for the use of laboratory space and equipment.

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[2] Biology Department and Allan Hancock Foundation, University of Southern California.

Coitocaecum Nicoll, 1915

Coitocaecum banneri n. sp.
Figs. 1, 2

SPECIFIC DIAGNOSIS: Based on seven specimens. Body smooth, oval, length 1.414–1.855, av. 1.683, greatest width 0.399–1.071, av. 0.858; oral sucker subterminal, length 0.21–.256, av. 0.241, width 0.196–.238, av. 0.217; acetabulum, length 0.308–.392, av. 0.348, width 0.252–.357, av. 0.329; prepharynx very short; pharynx oval, muscular, 0.096–.112, av. 0.106 long, and 0.088–.112, av. 0.096 wide; esophagus nearly as long as pharynx, glandular; ceca united near posterior end of body; gonads in posterior third of body, ovary pretesticular, smooth to weakly three-lobed, immediately to right of midventral line, 0.148–.224, av. 0.2 transversely, and 0.084–.126, av. 0.105 anteroposteriorly; seminal receptacle lacking; Laurer's canal present; Mehlis gland diffuse, lightly staining, immediately anterior to ovary; proximal uterine coils contain many sperm, uterine coils mainly intercecal and between ovary and acetabulum; metraterm short; eggs operculate, yellow, 0.048–.058, av. 0.056 long, and 0.027–.032, av. 0.03 wide; vitellaria richly developed, extending from about mid-esophageal level to posterior end of body, usually separated anteriorly but joining posteriorly, invading intercecal zone; testes postovarian, tandem to oblique, smooth to indented, posterior testis usually larger than anterior, anterior testis 0.231–.504, av. 0.334 long, and 0.108–.252, av. 0.167 wide, posterior testis 0.175–.49, av. 0.335 long, and 0.112–.291, av. 0.216 wide; seminal vesicle saccular, terminating shortly anterior to or slightly overlapping the acetabulum; cirrus sac short, cirrus weakly developed; genital pore ventral, on left side of body at postpharyngeal level; excretory bladder tubular, reaching to ovary, opening at posterior end of body.

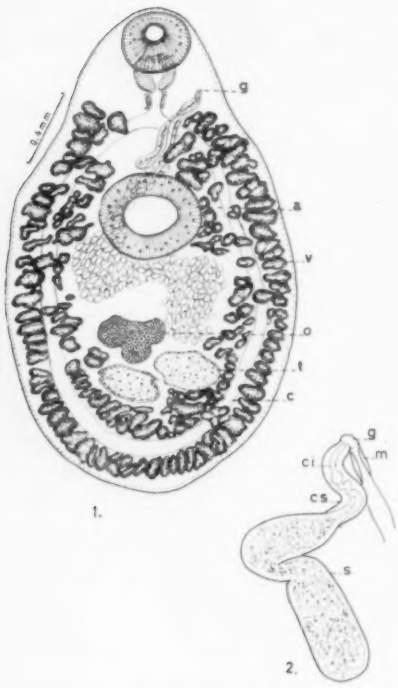

FIG. 1. *Coitocaecum banneri*, ventral view.
FIG. 2. *C. banneri*, terminal genital organs.

HOST: *Thalassoma duperrey* (Quoy and Gaimard), a wrasse. Hawaiian name: hinalea lauwili.

Three of seven fish infected; maximum number of worms, 4.

LOCATION: Gall bladder.

LOCALITY: Kaneohe Bay, Oahu, Hawaii.

TYPE SPECIMEN: *Coitocaecum banneri*, deposited as no. 569, Hancock Parasitology Collection.

Coitocaecum hawaiensis n. sp.
Figs. 3, 4

SPECIFIC DIAGNOSIS: Based on four specimens. Body smooth, spindle-shaped, length 0.801–1.435, av. 1.136, maximum width 0.385–.469, av. 0.418; oral sucker subterminal, 0.107–.13, av. 0.119 long, and 0.096–.12, av. 0.11 wide; acetabulum near mid-body, 0.192–.256, av. 0.223 transversely, and 0.166–.192, av. 0.82 anteroposteriorly; prepharynx short; pharynx oval, muscular, 0.08–.104, av. 0.089 long, and 0.064–.072, av. 0.071 wide; esophagus usually shorter than pharynx; ceca extend laterally and posteriorly to unite a short distance posterior to testes; gonads in posterior third of body, ovary pretesticular, on right side of body, oval to triangular, smooth, 0.084–.088, av. 0.086 long, and 0.056–.08, av. 0.071 wide; Mehlis gland immediately anterior to ovary; Laurer's canal present; seminal receptacle lacking; coils of uterus confined to intercecal area between gonads and acetabulum; metraterm about half the length of the cirrus sac; eggs yellow, operculate 0.048–.051, av. 0.05 long, and 0.024–.027, av. 0.026 wide; vitellaria richly developed, extending from pharynx level to near posterior end of body, invading intercecal zone, uniting anteriorly and posteriorly; testes immediately post-ovarian, tandem, smooth to slightly irregular, anterior testis 0.16 long, and 0.056–.064, av. 0.06 wide; posterior testis 0.128–.137, av. 0.132 long, and 0.08–.112, av. 0.093 wide; seminal vesicle saccular, terminating shortly anterior to or slightly overlapping acetabulum, surrounded by large cells with large nuclei; cirrus sac nearly as long as seminal vesicle and twice as long as metraterm; genital pore ventral, on left side of body at pharyngeal level, excretory bladder tubular, reaching to ovarian level, opening at posterior end of body.

HOST: *Thalassoma duperrey* (Quoy and Gaimard), a wrasse. In one of seven fish.

LOCATION: Gall bladder.

LOCALITY: Kaneohe Bay, Oahu, Hawaii.

TYPE SPECIMEN: *Coitocaecum hawaiensis*, deposited as no. 5610, Hancock Parasitology Collection.

Coitocaecum norae n. sp.
Figs. 5, 6

SPECIFIC DIAGNOSIS: Based on one specimen. Body smooth, oval, 1.05 long and 0.476 wide; oral sucker 0.144 by 0.128; acetabulum diameter 0.187; prepharynx short; pharynx oval, 0.048 long and 0.04 wide; esophagus approximately as long as pharynx, glandular, ceca extend lat-

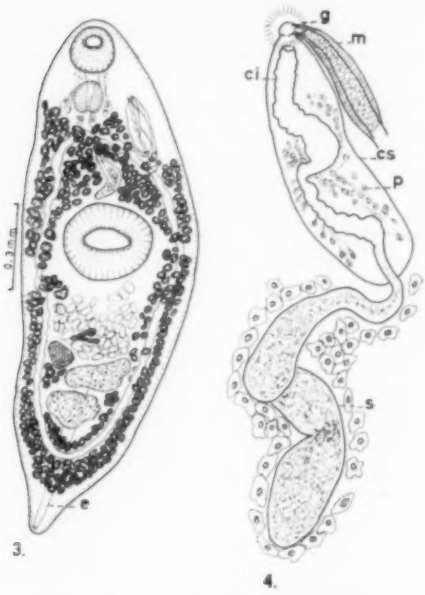

FIG. 3. *Coitocaecum hawaiensis*, ventral view.
FIG. 4. *C. hawaiensis*, terminal genital organs.

erally and posteriorly to unite near posterior end of body; gonads in posterior half of body, ovary pretesticular, three-lobed; Laurer's canal present; seminal receptacle lacking; Mehlis gland indistinct; uterine coils few, between ovarian and acetabular levels; metraterm short, relatively thick-walled; vitellaria extend from pharyngeal level to near posterior end of body, invading intercecal zone; eggs yellow, operculate, approximately 0.049 long and 0.029 wide; testes tandem, transversely elongate, lobed; seminal vesicle extends posteriorly to anterior margin of acetabulum; cirrus sac about twice as long as metraterm; cirrus weak, about same length as metraterm; common genital pore ventral, on left side of body, at mid-esophageal level; excretory bladder tubular, reaching to ovary, with thicker-walled posterior portion, opening terminally.

HOST: *Ctenochaetus strigosus* (Bennett). One of fourteen fish infected.

LOCATION: Gall bladder.

LOCALITY: Kaneohe Bay, Oahu, Hawaii.

TYPE SPECIMEN: *Coitocaecum norae*, deposited as no. 5611, Hancock Parasitology Collection.

The new species of *Coitocaecum* described in this paper are unique in living in the gall bladder, all other species of the genus having been recovered from the digestive tract. *C. banneri* seems to be closest to *C. orthorchis* Ozaki 1929, found in the stomach and intestine of *Tridentiger obscurus* Temminck and Schlegel at Hiroshima, and *Acanthogobius flavimanus* T. and S. from the fish market of Takamatsu City, Japan. Besides the differences of host and location within the host, *C. banneri* has larger suckers, a longer cirrus sac, and smaller eggs than *C. orthorchis*.

Coitocaecum hawaiensis also is close to *C. orthorchis* and *C. banneri*. It differs from both in having a well-developed cirrus sac and cirrus, in having the seminal vesicle surrounded by large cells, and in the union of vitellaria anteriorly.

Coitocaecum norae has lobed, transversely elongate and narrow (anteroposteriorly) testes that distinguish it from all other species of the genus.

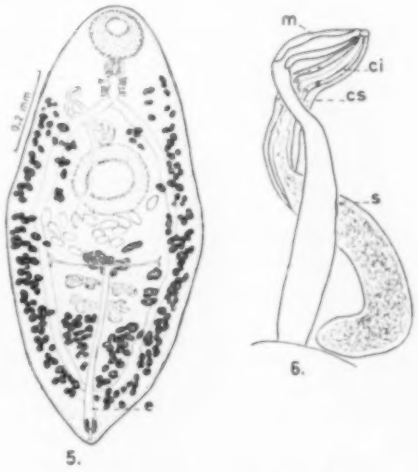

FIG. 5. *Coitocaecum norae*, dorsal view.
FIG. 6. *C. norae*, terminal genital organs.

Opecoelus lanceolatus n. sp.
Figs. 7, 8, 9

SPECIFIC DIAGNOSIS: Based on four specimens. Body elongate, narrow, smooth, 1.86–3.08, av. 2.4 long, and 0.364–.476, av. 0.394 maximum width; oral sucker subterminal 0.096–.112, av. 0.106 long, and 0.096–.112, av. 0.103 wide; acetabulum with five pairs of dactyls or papillae, the three median pairs longer than others, acetabulum 0.16–.172, av. 0.164 long, and 0.16 wide; prepharynx short; pharynx oval, 0.064–.08, av. 0.078 long, and 0.04–.058, av. 0.049 wide; esophagus approximately as long as pharynx; ceca extend laterally and posteriorly to join near the posterior end of body, rectum short, anus ventral, near posterior end of body; gonads in middle third of body, ovary pretesticular, oval to slightly indented; Mehlis gland diffuse, immediately anterior to ovary; Laurer's canal present; seminal receptacle lacking; uterine coils intercecal, mainly between ovary and acetabulum; metraterm short but slightly longer than cirrus sac; vitellaria extend from a short distance posterior to the acetabulum to the posterior end of body where they unite, mainly extracecal but slightly invading intercecal zone anterior to ovary and conspicuously between the testes and posterior to them; eggs yellow, operculate, 0.042–.048, av. 0.047 long, and 0.029–.032, av. 0.031 wide; testes tandem, one or both with indentation in posterior margin, anterior testis 0.179–.288, av. 0.24 long, and 0.09–.238, av. 0.188 wide; posterior testis 0.192–.32, av. 0.232 long, and 0.112–.224, av. 0.184 wide; seminal vesicle elongate, tubular, usually extending posterior to the acetabulum at least the diameter of the latter organ; cirrus sac short, enclosing prostatic cells and a weakly developed cirrus; common genital pore on left side of body, at or near posterior pharyngeal level; excretory vesicle tubular, reaching to or near ovary, opening terminally.

HOST: *Mulloidichthys samoensis* (Gunther), a goatfish. Four of ten fish infected.

LOCATION: Intestine.

LOCALITY: Kaneohe Bay, Oahu, Hawaii.

TYPE SPECIMEN: *Opecoelus lanceolatus*, deposited as no. 5612, Hancock Parasitology Collection.

Opecoelus lanceolatus seems to be closest to *O. xenistii* Manter, 1940, found in the intestine of *Xenistius californiensis* (Steindachner) collected at Tagus Cove, Albemarle Island, Galapagos. It differs from *O. xenistii* in the following ways: the vitellaria do not extend anteriorly as far as the acetabulum, the metraterm is much shorter, and the ovary is not trilobed.

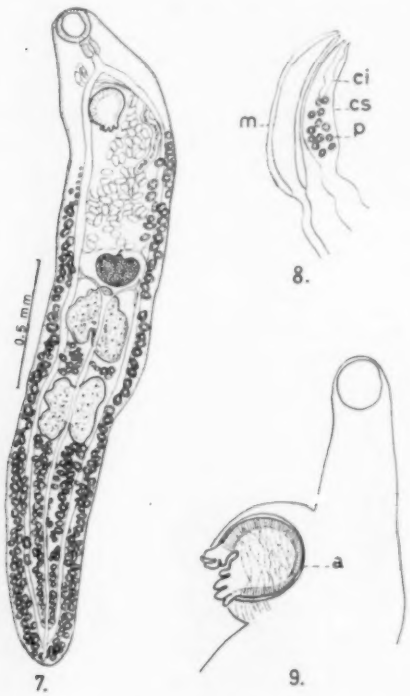

FIG. 7. *Opecoelus lanceolatus*, dorsal view.
FIG. 8. *O. lanceolatus*, terminal genital organs.
FIG. 9. *O. lanceolatus*, side view to show dactyls on acetabulum.

Pseudopecoeloides tenuoides n. sp.
Figs. 10, 11

SPECIFIC DIAGNOSIS: Based on eight specimens. Body elongate, slender, smooth, somewhat constricted at gonad levels, 2.555–5.04, av. 3.47 long, and 0.16–.5, av. 0.3 wide; oral sucker subterminal 0.22–.28, av. 0.243 long, and 0.18–.23, av. 0.193 wide; acetabulum pedunculate

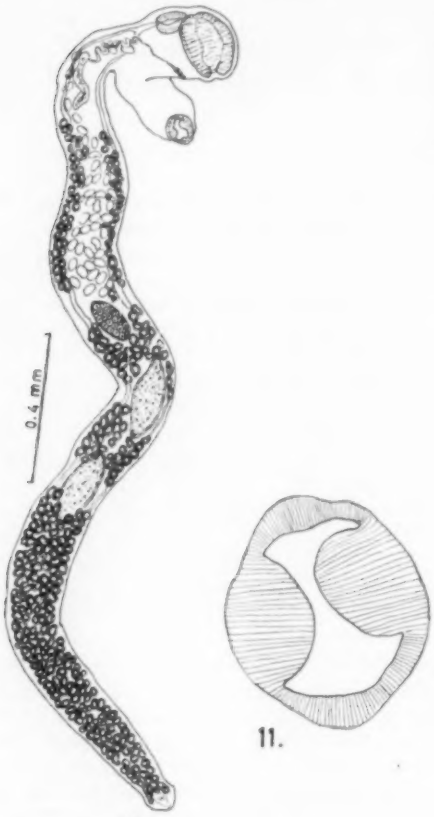

FIG. 10. *Pseudopecoeloides tenuoides.*
FIG. 11. *P. tenuoides,* acetabulum showing pads.

with thick pads, 0.068–.118, av. 0.098 long, and 0.087–.109, av. 0.096 wide; prepharynx short; pharynx 0.087–.124, av. 0.1 long, and 0.65–.081, av. 0.068 wide; esophagus up to two-thirds length of pharynx; ceca proceed laterally and posteriorly to unite with excretory bladder near posterior end of body; gonads in middle third of body; ovary pretesticular, oval to spindle-shaped, smooth, 0.131–.211, av. 0.18 long, and 0.062–.143, av. 0.096 wide; Mehlis gland immediately anterior to ovary; Laurer's canal present; seminal receptacle lacking; uterine coils mainly between ovary and seminal vesicle; metraterm indistinct; eggs oval, operculate, 0.040–.050, av. 0.044 long, and 0.025–.037, av. 0.030 wide; vitellaria well developed beginning a little posterior to the seminal vesicle and extending to near the posterior end of body, interrupted at gonad levels; testes spindle-shaped, smooth, tandem, anterior testis 0.187–.336, av. 0.267 long and 0.093–.146, av. 0.115 wide, posterior testis 0.218–.348, av. 0.292 long, and 0.093–.124, av. 0.111 wide; seminal vesicle tubular with a coiled narrow duct; prostate cells fairly numerous; cirrus rudimentary, a cirrus sac was not observed; genital opening ventral, sinistral, approximately midway between suckers; excretory vesicle tubular extending to or near ovary, opening terminally as a cloaca.

HOST: *Priacanthus cruentatus* (Lacépède). Four of seven fish infected; maximum number of worms, four.

LOCATION: Intestine.

LOCALITY: Kaneohe Bay, Oahu, Hawaii.

TYPE SPECIMEN: *Pseudopecoeloides tenuoides,* deposited as no. 5613, Hancock Parasitology Collection.

Pseudopecoeloides tenuoides is closest to *P. tenuis,* described by Yamaguti (1940) from the small intestine of *Pseudopriacanthus nipponicus* (Cuv. et Valenc.), collected at Hamazima, Mie Prefecture, Japan. *P. tenuoides* differs from *P. tenuis* in having smaller eggs, a smaller oral sucker, smaller acetabulum, and in having acetabular pads.

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A Comparison of the Ammocoete and Macrophthalmia Stages of *Mordacia mordax* and *Geotria australis* (Petromyzonidae)

R. STRAHAN[1]

VERY LITTLE IS KNOWN of the biology of the lampreys of the Southern Hemisphere. On the available evidence (Strahan, 1959), there appears to be only one species of *Geotria*, *G. australis* Gray 1851, extending from Western Australia eastwards to the Falkland Islands. Almost nothing is known of its distribution while in the marine stage of its life history. The northern limits of its distribution in estuaries and rivers appear to be 32° S. on the west coast of Australia and 37° S. on the east coast of Australia and the North Island of New Zealand; 40° S. on the west coast of South America and 35° S. on the east coast. It extends southwards to Tasmania, the South Island of New Zealand, and Tierra del Fuego.

Three species of *Mordacia* have been described. *M. mordax* (Richards) 1846 has a north–south distribution similar to that of *Geotria australis* but is restricted to the Pacific coasts of Australia (where it extends northwards to about 34° S.) and of South America. The other two species, *Mordacia lapicida* (Gray) 1851 and *M. acutidens* (Philippi) 1863, are apparently restricted to the Pacific coast of South America (Plate, 1902; Lahille, 1915; Holly, 1933; Mann, 1954).

In the course of the past century, *Geotria australis* was divided into as many as seven genera and nine species. This seems to have been due partly to enthusiastic "splitting," but more to ignorance of the life history of the species, which is now known to comprise well-marked ammocoete, "macrophthalmia," "velasia," and adult stages (Maskell, 1929; Strahan, 1959). In the almost complete absence of information on the life history of any species of *Mordacia*, the possibility arises that a similar confusion exists here. Mann (1954) has suggested that the Chilean forms described as *Mordacia* are the late developmental stages of *Geotria*, but this is unlikely since the dentition of *Mordacia* is very characteristic, it being the only lamprey with two supraoral laminae on the buccal funnel. Certainly the situation cannot be clarified until more is known of the development of *Mordacia*.

Maskell (1932) stated that the ammocoete of *Mordacia* has one intestinal (exocrine pancreatic) diverticulum on the left side of the oesophagus, and can thereby be distinguished from the ammocoete of *Geotria*, which has both right and left diverticula, and from the ammocoete of Petromyzon, which has no diverticula. However, the question arises. How did Maskell know that the ammocoetes with only one diverticulum were referable to *Mordacia*? The only author to comment upon the external appearance of *Mordacia* ammocoetes was Ogilby (1896), who stated that the dorsal and caudal fins are continuous in the ammocoete but separate in the adult. This is also characteristic of *Geotria*. Some of Maskell's *Mordacia* ammocoetes were obtained from the Australian Museum, Sydney, N.S.W. Since they were demonstrably not *Geotria*, they could have belonged only to *M. mordax* or, rather improbably, to some undescribed Australian lamprey. Others were obtained from the British Museum (Natural History), London, and their place of collection is not recorded. It is probably fortuitous that these were correctly identified. Conclusive proof of identity depends upon establishing a series of intermediate stages between the ammocoete and identifiable postmetamorphic individuals.

DESCRIPTION OF MACROPHTHALMIA OF *M. mordax*

The author had the good fortune recently, while revising the British Museum collection of lampreys from the Southern Hemisphere, to find

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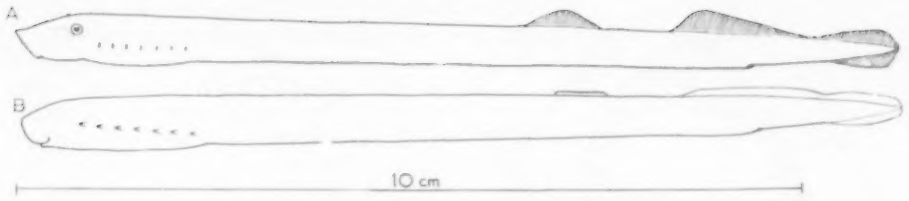

FIG. 1. *A*, Macrophthalmia stage; *B*, Ammocoete of *Mordacia mordax*.

a jar of ammocoetes labelled, "*Geotria*, 1925, from Sydney, N.S.W." For want of better knowledge, this diagnosis might have been accepted, had the jar not also contained a macrophthalmia (a large-eyed, recently-metamorphosed stage) which was markedly different from the macrophthalmia of *G. australis*. It possessed two tricuspid supraoral laminae which showed it to be a *Mordacia*, and three conical teeth anterior to the supraoral lamina and separating the rows of lateral tooth plates, which identified it as *M. mordax*. This stage in the life history of the species has not previously been recorded or described.

The specimen, which is preserved in alcohol, is of a uniformly pale yellowish-brown colour, as are the ammocoetes with it. The body is laterally compressed, much more so than in an ammocoete of the same length. It is 122 mm. long, being about 2 cm. shorter than the largest ammocoete in the sample. The eye is large and prominent and the iris has a silvery sheen. Measuring from the anterior tip of the head, the nasal aperture lies at 6 mm. and the centre of the eye at 7 mm. Eight lateral line pits form an infraorbital series and no other lateral line organs are discernible. The branchial region extends from 12 mm. to 22 mm. The first dorsal fin arises at 70 mm. and extends to 76.5 mm.; the second dorsal fin extends from 88 mm. to 108.5 mm. and is contiguous with the caudal fin. All the fins have distinct fin rays and are rather triangular in profile, differing from the fins of the ammocoete, which take the form of a low quadrilateral. The anterior border of the cloacal aperture lies 102 mm. from the anterior end of the body (Fig. 1*A*).

The mouth aperture is oval in shape, being longer longitudinally than transversely (Fig. 2). When opened to its full extent, its diameter is less than the diameter of the body. The mouth is surrounded, except posteriorly, by small, bluntly conical cirri lying just outside the rim of the buccal funnel. Just within the rim is a complete series of small, flat, fringed processes lying closely side by side. Two large supraoral tooth plates lie just anterior to the centre of the buccal funnel, separated from each other by a distance equal to the width of a tooth plate. Each tooth plate bears three sharp-pointed cusps which are directed posteriorly. From the shape of the tooth plates, it appears that each tricuspid plate may have arisen by the fusion of three unicuspid elements. Anterior to the supraoral tooth plates and in the mid-line are three small unicuspid teeth arranged in a triangle with the apex pointing anteriorly. On the right and on the left side of the buccal cavity is a series of five small bicuspid lateral tooth plates arranged radially. Posteriorly, external to the infraoral lamina, is a series of eight bicuspid tooth plates, also having a radial orientation. The infraoral lamina bears nine low, pointed cusps, the penultimate of these at each end being slightly higher than the others. The anterior lingual tooth plate has a finely serrated edge. The two posterior lingual tooth plates cannot be seen very well in the specimen.

COMPARISON OF MACROPHTHALMIA STAGES OF *G. australis* AND *M. mordax*

The macrophthalmia of *G. australis* has been described by Maskell (1929) and it is unnecessary to repeat the description here. Table 1 summarizes the differences between the macrophthalmia stages of the two species.

Apart from the dentition, which alone is sufficient to separate the macrophthalmia stages of

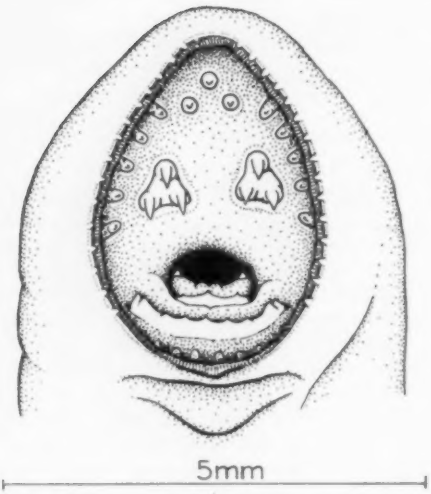

FIG. 2. Ventral view of head of macrophthalmia of *Mordacia mordax*.

the two species, another striking difference between them is the more posterior position of the cloacal aperture in *M. mordax*. This is expressible in relation to the total length of the body, in relation to the anterior border of the second dorsal fin, or in the number of precloacal myomeres.

COMPARISON OF AMMOCOETES OF *G. australis* AND *M. mordax*

It was possible that the *Mordacia* macrophthalmia had been accidentally included in a sample of *Geotria* ammocoetes, but examination of these showed that in the position of the cloaca they closely resembled the *Mordacia* specimen and differed from known ammocoetes of *Geotria* (Table 2). Dissection of several of the ammocoetes revealed that each possessed only one intestinal diverticulum, thus confirming Maskell's original observation. Figure 1*B* shows the body proportions of an ammocoete 123 mm. long.

DISCUSSION

It is unfortunate that the sample of *Mordacia* ammocoetes contained no smaller specimens which could be compared with small specimens of *Geotria*. However, the great uniformity in proportions over the length range, 100–160 mm., suggests that smaller ammocoetes of *M. mordax* would also be distinguishable by the position of the cloaca. In adult specimens of *Mordacia* the cloaca is found at 83–84 per cent of the length of the body, there being no difference in this respect between *M. mordax*, *M. lapicida*, or *M. acutidens* specimens in the British Museum. In the velasia stage of *G. australis* the cloaca occupies almost the same position as in the macrophthalmia and the ammocoete. Eleven unpouched specimens had the cloaca at 77 ± 1 per cent of the total length. However, the resorption of the tail tissues, consequent upon the cessation of feeding in the adults, causes a relative backward shift in the position of the cloaca and the first dorsal fin. In 11 pouched adults, these occurred at 79 ± 3 per cent of the total length.

TABLE 1

COMPARISON OF MACROPHTHALMIA STAGES OF *Mordacia mordax* AND *Geotria australis*, BASED ON ONE SPECIMEN OF *M. mordax* AND SIX SPECIMENS OF *G. australis*

(Standard deviations calculated for all means)

	M. mordax	*G. australis*
Total length (T. L.)	122 mm.	103 ± 5 mm.
Tip of head to origin of first dorsal fin	57% of T. L.	58 ± 1% of T. L.
Tip of head to origin of second dorsal fin	72% of T. L.	76 ± 1% of T. L.
Tip of head to anterior border of cloaca	83% of T. L.	76 ± 1% of T. L.
Number of precloacal myomeres	102	93 ± 2
Supraoral lamina	two, each with 3 cusps	one, with 4 cusps
Pair of enlarged lateral buccal cirri	absent	present
Coloured dorsal stripes	absent*	present

* The skin of this specimen is very similar to that of an ammocoete, having no metallic lustre. It is possible that the specimen is incompletely metamorphosed in this respect or that the specimen became decolourized by preservation.

TABLE 2

POSITION OF THE CLOACA IN AMMOCOETES OF *Mordacia mordax* AND *Geotria australis*

M. mordax				*G. australis*			
Total length (mm.)	Head to cloaca		No. of precloacal myomeres	Total length (mm.)	Head to cloaca		No. of precloacal myomeres
	mm.	% of T. L.			mm.	% of T. L.	
102	84	82	104	37	29	78	92
111	93	84	103	44	35	80	90
121	101	83	102	52	41	79	91
130	109	84	103	55	44	80	90
131	111	85	101	61	50	82	93
132	110	83	101	73	57	78	89
135	113	84	103	83	64	77	91
140	118	84	103	84	64	76	95
145	120	83	102	87	67	77	90
160	135	84	103	89	68	76	92
		84 ± 1%	103 ± 1.0			78 ± 2%	91 ± 1.7

It is noteworthy that the largest ammocoete of *M. mordax* in the sample (160 mm. long) is much longer than the largest ammocoete of *Geotria* recorded by Maskell (1929) from New Zealand (104 mm. long), or by the author, from Western Australia (100 mm. long). This is the opposite condition to that of the adults. Fourteen specimens of *M. mordax* in the National Museum of Victoria, Melbourne, ranged from 21 to 42 cm. in length (average 33 ± 5 cm.), while 22 specimens of *G. australis* from the same collection ranged from 34 to 58 cm. in length (average 47 ± 7 cm.). This condition of a relatively larger larva and relatively smaller adult suggests that, compared with *Geotria*, *M. mordax* has a tendency to neoteny.

SUMMARY

A single macrophthalmia stage of *Mordacia mordax* is described. Its dentition is very similar to that of the adult and thus is different from that of *Geotria australis*.

Although in general body form the ammocoetes and the macrophthalmia stages of the two species are very similar, the cloaca is more posterior in *Mordacia*, lying at 84 ± 1 per cent of the total length of the body, well behind the origin of the second dorsal fin, and with 103 ± 1 precloacal myomeres. *Geotria* has the cloaca at 78 ± 2 per cent of the total length, just below the origin of the second dorsal fin, and with 91 ± 1.7 precloacal myomeres. This character serves to distinguish premetamorphic stages of the two Australian species. It is also relatively constant in older stages, except in the secondarily shortened mature adults of *Geotria*.

The ammocoetes of *M. mordax* grow to a greater length than those of *G. australis*, whereas the adults are shorter. This suggests a relative tendency towards neoteny in *M. mordax*.

ACKNOWLEDGMENTS

The author wishes to express his thanks to the curators of the Western Australian Museum, the National Museum of Victoria, and the British Museum (Natural History), for granting access to their collections of lampreys.

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NOTES

Courtship Behavior of the Lined Shore Crab, *Pachygrapsus crassipes* Randall

RICHARD V. BOVBJERG[1]

IN HIS DEFINITIVE MONOGRAPH on the biology of the lined shore crab of the Pacific, an important member of the high intertidal community and useful to physiologists, Hiatt (1948) describes the copulation pattern of this species from repeated observations. Having seen little preliminary activity, he precludes extensive prenuptial behavior. On the basis of several observations of courtship behavior in this species that I have made, the opportunity to extend Hiatt's data prompts this note.

These observations were made on crabs kept in laboratory bowls in the course of ecological work to be reported elsewhere. The following sequence is typical of this courtship behavior.[2]

The pattern is overtly initiated by the male's approaching a female in a threat posture with chelae extended. However, this is not followed by the usual strike. The female is instead pushed —one is tempted to say, gently—with the chelae flexed horizontally. The female reaction to this gesture is a deliberate retreat, in which she is closely followed by the male. Lateral movements by the female are countered by the male, in a manner which may best be described as herding. This initial phase may end in a radical escape movement by the female, and as such is identical to a male-to-male herding activity by the more dominant individual. This first phase may last from less than a minute to several minutes.

If the female is acceptant, the second phase is marked by the cessation of herding and a retreat by the male, closely followed by the female. The tempo of movement increases as the activity becomes a courtship dance. The pair moves in complete synchrony, chelae to chelae but not grasping. The movements are of two sorts: a forward and backward as well as lateral walking, and a lateral swaying movement of the body without walking. The intensity and synchrony increase for a period up to a minute or two. This phase is culminated during a backward movement by the male as he rolls onto his back with the female walking over him in the characteristic dorsal copulatory position of the female described by Hiatt (1948).

Sexual harmony is the striking product of this behavior; in the courtship activities the male at no time forcibly holds the female, nor (in corroboration of Hiatt's observations) is there aggressive grasping during copulation. However, the initial phase is definitely a type of male aggression and may end in a strike or a fight. In like manner, the postcopulatory male behavior may return to the aggressive pattern. While some pairs separate and proceed independently, in others only one partner is released from the sexual sequence. In one instance the female escaped following copulation and the male transferred immediately to a second female. Conversely, another copulation ended with the female still in the following sequence and the male returning to the aggressive role with a violent strike at the female. This close relationship between sexual and aggressive behavior would seem to be characteristic of many decapod crustaceans (Andrews, 1895; Chidester, 1911; Crane, 1941; Bovbjerg, 1946) and indeed of many vertebrates.

No investigation was made of the cues involved, though Hiatt (1948) notes sexual be-

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[2] Dr. Richard A. Boolootian, Department of Zoology, University of California at Los Angeles, personal communication, has observed at least some aspects of this behavior and has recorded these in some of his motion picture studies.

havior of males with males and with the cast skin of a female. It is tempting to compare this crab pattern to the now classical picture of the stimulus-reaction chain of the three-spined stickleback (Tinbergen, 1951).

The complexity of the sexual behavior of *P. crassipes* seems to have no parallel among the Crustacea with the exception of the genus *Uca*, where Crane (1941) found species differences in sexual posturing and a complex and variable pattern of courtship. The behavior cited in the present report may be equally variable under natural conditions. The singularity of such complex behavior patterns in crustaceans may be more apparent than real when the amount of investigation devoted to them is considered relative to that given to insects and vertebrates.

ACKNOWLEDGMENTS

These observations were made at the Hopkins Marine Station of Stanford University while I was there as Acting Associate Professor of Biology in Marine Ecology during the summer of 1958. I wish to take this opportunity to express my gratitude to the entire staff of the station, and to its director, L. R. Blinks, for their encouragement and stimulating company.

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Flora Malesiana: A Review

BENJAMIN C. STONE[1]

FLORA MALESIANA, "an Illustrated Systematic Account of the Malaysian Flora"; published under the auspices of the Kebun Raya Indonesia, Bogor, Java, the Botanic Gardens of Indonesia, and the Rijksherbarium, Leyden, Netherlands; prepared on an international cooperative basis; general editor, Dr. C. G. G. J. van Steenis, Director of the Flora Malesiana Foundation; published by Noordhoff-Kolff N.V., Djakarta. Published to date: three volumes of series I, e.g., I (1), I(4), and I (5), as follows: 1: i-clii, 1-639 (1950); 4: i-ccxix, 1-631 (1948-54); 5: i-ccxlii, 1-595 (1955-58).

Volume I comprises a cyclopaedia of collectors, with introductory chapters on methods and aims of the work, techniques of plant-collecting in the tropics, phytogeography of Malaysia, history of collections, desiderata for future collectors, and sources of information for the cyclopedic part.

Volume 4 contains an introduction and general considerations (by van Steenis), a history of the descriptions of Malaysian plants (by H. C. de Wit), keys (by van Steenis), dates of publication of source works (by M. J. van Steenis-Kruseman and W. T. Stearn), and a series of taxonomic revisions of more than 60 families (by various authors).

Volume 5 consists of a list of selected bibliography, abbreviations used in citations, a long part on the philosophy of specific and infraspecific delimitation, and a supplement (no. I) to the cyclopaedia of collectors, and further revisions (of 24 families, by various authors), with indices.

The series I, Spermatophyta, (and presumably the other series, to include other plant groups) contains, besides the various other types of information, the core of the work, which is a revised modern systematic treatment of the plants of Malaysia, with keys, diagnoses, references, synonyms, distributional notes, ecological notes, and information pertaining to the uses of both wild and cultivated species.

The undertaking is an enormous one of the greatest importance, and the perseverance of the editors and the quality of this achievement, in spite of considerable difficulties (not the least of which has been the split in Dutch-Indonesian relations resulting in a lack of financial support) has excited both admiration and awe.

From a botanical point of view, the *Flora* commands the greatest respect. The editorial policy is exemplary, resulting in a uniform treatment that makes for clarity; while the numerous scientists, many working in Holland, but others in other countries, have maintained the highest standards in their work. Especially valuable is the section in volume 5 on specific and infraspecific delimitation. Although on occasion verging on redundancy, there is a great deal of wisdom in it, of both the practical and the philosophical kind, drawn from long experience with tropical plants. This section ought to be required reading for all botanists, especially those who are working with tropical plants. At the end of this section 70 precepts are listed, intended both as guides for preparers of the *Flora* and to botanists in general. The last two bear repeating here: "Phytography requires besides a love and esteem for the métier, a memory for forms, great patience and care, a never-ending self-criticism, continuous concentrated observation of details, a great tenacity for mastering facts, as well as a balanced and unprejudiced outlook." "Be always prepared to solicit disinterested criticism from experienced colleagues whose work you admire. Try to conquer a natural, human dislike and inertia to drastic improvements and emendations in agreement with your responsibility."

[1] Department of Botany, University of Hawaii.
Manuscript received January 28, 1960.

Other significant points brought out are the need for monographic studies, rather than haphazard or localized floristic articles; the utilization of all sources of information; the synthesis, as well as the analysis, of data; brevity and clarity; conservative and meaningful taxonomy.

An interesting aspect of the work is the fact that at present it is printed entirely in English, even though begun primarily by Dutch scientists. Equally valuable is the area encompassed by the contents, including Java, Borneo, Sumatra, Celebes, the Malayan peninsula, the Philippines, New Guinea, and the myriad lesser islands in this vast area. That political boundaries have been overlooked in the favor of natural biogeographical areas is further evidence of the wise and broad perspective of the editor and his staff.

In the revisions, very full keys are presented, often two or three for each genus, in order to make as easy as possible the identification of specimens, whether sterile, in flower, or in fruit. The completeness of the documentation is beyond reproach. Synonymy is included. Illustrations are numerous; photographs and line drawings, both of very high quality, add a great deal to the value of the revisions. A few new species are described in the revisions.

To date, mainly the smaller families have been treated, but several moderately large groups—the Burseraceae, Flacourtiaceae, and Rhizophoraceae—have been completed. They are published as they are completed, rather than in any particular order. This procedure allows for the completion of volumes of comparable size in serial order, rather than bringing out innumerable small unbound parts belonging to widely scattered volumes. The binding is in handsome green leatherette and seems to be durable. The paper is of a high quality off-white nonglossy rag stock.

The only serious drawback to the work lies in its high cost, which in the United States amounts to between $20 and $30 per volume. Because of the withdrawal of government support by the Indonesian government, the price was raised beyond early expectations. Nonetheless, the intrinsic value of the work, together with the fact that payment for future volumes will be extended over a period of years, somewhat mollifies even the private buyer. For universities, museums, libraries, and most taxonomists or other botanists interested in the Malaysian flora, the acquisition of the series is almost mandatory. The series, when completed, undoubtedly will be the standard reference work of its type for the area for centuries to come.

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